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Journal

—OF THE—

American Ceramic Society

A Monthly Journal devoted to the Arts and Sciences Related to the Silicate Industries.

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JOURNAL
OF THE
AMERICAN CERAMIC SOCIETY

A monthly journal devoted to the arts and sciences related to the silicate industries.

Vol. 1 **January, 1918** **No. 1**

EDITORIALS.

TO THE PUBLIC:

The American Ceramic Society announces the publication of the JOURNAL OF THE AMERICAN CERAMIC SOCIETY, the official organ of the Society.

The American Ceramic Society was founded in 1899, for the avowed purpose of "promoting the arts and sciences connected with Ceramics, by means of meetings, for the reading and discussion of professional papers, and by the publication of professional literature."

Up to this time, the publication of this Society has taken the form of a volume of Transactions containing the papers presented at the annual meeting.

At the annual meeting in February, 1918, the Society, realizing the need for a greater activity in the field of Ceramics, authorized the publication of a monthly journal to be devoted "to the Arts and Sciences related to the Silicate Industries." THIS JOURNAL, by reason of the high standards of the American Ceramic Society and because of the advances which this country is making in all that pertains to Ceramics, may well be expected to take first place in the world's contributions to the science and technology of the industries to which it is devoted.

It is to be hoped that it may find a place in every public and institutional library of this country, as additional service to the reading public in general, and to technical men in particular.

COMMITTEE ON PUBLICATIONS.

THE FUEL CURTAILMENT ORDERS.

The Ceramic industry and especially the building materials branch has been vitally interested in the curtailment orders issued by the U. S. Fuel Administration on April 23rd. The orders were the direct result of the fuel shortage of last winter when, in some sections of the country, plants vitally necessary to the conduct of the war were closed down partially or completely for months, on account of lack of coal.

It was quite natural that the building material industry should be selected as the first to be curtailed, as the entire industry consumes approximately 32,000,000 tons of fuel annually, the clay-working branch consuming about one-third of this amount, or 10,000,000 tons. The industry being ranked as a "peace-time essential," and not a "war essential," offered a better opportunity for a larger diversion of fuel than any other industry. Furthermore, as it was found that for every ton of fuel consumed, this industry puts into transportation channels approximately three tons of raw and finished products, a total of 90,000,000 tons, a curtailment in production would result in considerable relief to the badly overtaxed transportation system.

It was never the intention of the Conservation Division of the U. S. Fuel Administration to curtail all non-war industries or to curtail any industry to a point where the demand could not be taken care of by the industry at large. Every effort was made to correctly estimate the demand on each industry for the year 1918 and the percentages used in the orders represent the estimated minimum, not the maximum. One of the principal aims of the orders was to prevent the use of fuel in producing material that would not be used this year, in other words, in producing stock. It is a well-known fact that a manufacturing concern "can do anything but shut down," but under the present conditions, it was out of the question to allow a single ton of fuel to be used unless it was absolutely necessary.

A close study of the orders with their "exception clauses" will show how easy it is for any manufacturer to get a permit to produce more than the minimum, provided, of course, he can show that he has orders for the material, and provided, also, that there is more than sufficient fuel in his district to take care

of the domestic demands and the war industries. These clauses were put into the orders especially for the benefit of those industries in the "red flag" districts, which were working on government orders, and of the plants in the western and southern sections which were not affected by a fuel shortage. Outside of the triangle bounded by lines drawn from Pittsburgh to Boston and from Pittsburgh to Baltimore, known in the Fuel Administration as the "Red Flag District," it is hardly expected that any plant will be refused a permit to produce beyond the minimum specified in the orders, provided they have legitimate orders which are acted upon favorably by the War Industries Board.

. Some criticism has been heard from members of the affected industries because very few other industries have been curtailed. There are a great number of good reasons for this. Many industries not curtailed specifically, have been denied fuel by the Federal Fuel Distributers, others have been under almost continuous embargoes issued by the Director General of Railroads, still others, and there are many of these, have been denied raw materials by the War Industries Board.

The cement industry may be taken as an illustration. No curtailment order has been issued to date covering this industry, for the reason that the cement output of the country has been at below fifty per cent. of normal during the first five months of this year. This was entirely due to the plants in the eastern half of the country being denied fuel. In many cases a whole industry uses such a small amount of fuel that a curtailment order would produce negative results, so far as fuel diversion is concerned.

The latest move of the Fuel Administration has been to organize an "Industrial Furnace Section." As the Ceramic industry is the largest user of fuel coming under this heading, with the exception of the steel and coke industries, a great amount of effort will be devoted to it by this new section. Knowing that there is much unnecessary waste in the use of fuel for manufacturing purposes, the section will attempt to conserve fuel through cutting this waste down to a minimum.

Those connected with the various industries can be of great

assistance to the government by starting at once to look over the plants with which they are connected and locating any possible leak. Uninsulated steam pipes, badly cracked kilns, poor burning practice, steam leaks and poorly aligned shafting should be especially looked after.

The section will appoint a force of field inspectors who will inspect each plant and advise with the management. Reports will be made to the Chief of Section with recommendations for changes that will produce further economy. An educational campaign will also be carried on through bulletins and the trade magazines. Every effort will be made to bring about the desired results without using the power conferred upon the Fuel Administration by the Lever Act.

It is naturally expected that the technical men connected with the industries, and especially those associated with the American Ceramic Society will grasp the splendid opportunity offered to assist the country in this time of stress. Many have devoted a great deal of time, for years past, in an effort to conserve our fuel resources, but it has taken a great war to bring the government to the point where it is willing to back them up and even to use compulsion if necessary, to bring about results. It takes little though to foresee the benefits that will result and permanently remain after the war is over.

THE NATIONAL RESEARCH COUNCIL.

The following Executive Order, defining the duties of the National Research Council, was issued recently by the President:

1. In general, to stimulate research in the mathematical, physical and biological sciences, and in the application of these sciences to engineering, agriculture, medicine and other useful arts, with the object of increasing knowledge, of strengthening the national defense, and of contributing in other ways to the public welfare.

2. To survey the larger possibilities of science, to formulate comprehensive projects of research, and to develop effective means of utilizing the scientific and technical resources of the country for dealing with these projects.

3. To promote coöperation in research, at home and abroad, in order to secure concentration of effort, minimize duplication, and stimulate progress; but in all coöperative undertakings to give encouragement to individual initiative, as fundamentally important to the advancement of science.

4. To serve as a means of bringing American and foreign investigators into active coöperation with the scientific and technical services of the War and Navy Departments and with those of the civil branches of the Government.

5. To direct the attention of scientific and technical investigators to the present importance of military and industrial problems in connection with the war, and to aid in the solution of these problems by organizing specific researches.

6. To gather and collate scientific and technical information at home and abroad, in coöperation with Governmental and other agencies and to render such information available to duly accredited persons.

Effective prosecution of the Council's work requires the cordial collaboration of the scientific and technical branches of the Government, both military and civil. To this end representatives of the Government, upon the nomination of the National Academy of Sciences, will be designated by the President as members of the Council, as heretofore, and the heads of the departments immediately concerned will continue to coöperate in every way that may be required.

(Signed) WOODROW WILSON.

THE WHITE HOUSE,
May 11, 1918.

The work in ceramics, which is carried out under the auspices of the Research Council is in the hands of three committees: (1) the Committee on the Chemistry of Cements and Related Building Materials, Prevost Hubbard, Chairman, office of Public Roads and Rural Engineering, U. S. Department of Agriculture, Washington, D. C.; (2) the Committee on the Chemistry of Glass, Arthur L. Day, Chairman, Geophysical Laboratory, Washington, D. C.; (3) the Committee on the Chemistry of Ceramics, Edward W. Washburn, Chairman, University of Illinois, Urbana, Ill.

The last-named committee covers all branches of ceramics not covered by the first two committees. In a future issue we expect to present further details concerning the work of these committees.

EDWARD ORTON, JR.

On February 17, 1898, ten men met in the old Monongahela Hotel, Pittsburgh, Pa., to discuss, in an informal fashion, the possibility of organizing a technical ceramic society. This subject had previously been discussed by Professor Edward Orton, Jr., and Mr. S. Geijsbeek and the time seemed ripe for such a venture. Professor Orton was at that time Director of the only Department of Ceramic Engineering in the United States, having been the pioneer in the application of academic instruction to this field of technology. He had already attained leadership in technical ceramics and was at once looked upon as the guiding spirit of the initial meeting and of all subsequent efforts which led to the formal organization of the American Ceramic Society, a year later. The task of organizing a group of men for this purpose was by no means an easy one. The spirit of conservatism, the clinging to cherished trade secrets, and the more or less well-defined doubt as to the value of the technical study of ceramic subjects, had to be overcome and men won over to the cause of advancement. Orton's perseverance and his potent personality attracted seventeen men willing to become charter members of the proposed organization. His accomplishment may not appear to have been difficult of execution, to the younger generation of today, but those who knew the conditions of twenty year ago will appreciate the magnitude of the task. Professor Orton had prepared for the first meeting an interesting program, which increased the enthusiasm of the charter members and caused others to join the Society. The meeting was a complete success and the novelty of the frank discussion of technical matters aroused wide interest.

With all the powers of his vigorous nature, the subject of this sketch threw himself into the work of completing the organization of establishing the rules, and of adopting a policy which has remained as the foundation of our organization to this day. He attracted to the Society the leading spirits of the ceramic world and created a delightful atmosphere of good-fellowship, existing in but few technical societies. He, nevertheless, insisted upon continuous hard work on the part of the membership and, step

Edward Orton Jr.

by step, he led the organization to the position it now occupies in the industrial world.

Professor Orton has served the American Ceramic Society as Secretary for twenty years, giving to this work his whole-hearted devotion and making sacrifices of such magnitude that any expression of our appreciation of his services seems feeble and inadequate. We are so utterly in his debt.

Finally, when his country called her men to arms, Professor Orton obeyed with characteristic promptness and is now serving as Major in the Department of the Quartermaster General.

For a brief biography of our subject, we copy the following paragraph from "Who's Who in America:"

"Professor Edward Orton, Jr., was born in Chester, N. Y., October 8, 1863. His parents were Dr. Edward and Mary (Jennings) Orton. Mining Engineer, Ohio State University, 1884. On October 3, 1888, he married Mary Princess Anderson, of Columbus, Ohio. Chemist and Superintendent of blast furnaces, 1884–8. The first regular manufacturer of 'ferro-silicon,' or high silicon alloy of iron, in the United States, Bessie Furnace, New Straitsville, Ohio, 1887–8. Entered clay industries in 1888 and managed several plants 1888–1893. In 1893 he began an agitation which resulted in establishing in 1894 the first school in the United States for instruction in the technology of the clay, glass, and cement industries, of which he was continuously, to the spring of 1916, the Director, at which time he was elected to Research Professorship in Ceramics. Dean of College of Engineering, Ohio State University 1902–6, and 1910–16. State Geologist of Ohio, 1899–1906. Fellow A. A. A. S. Member of the Society of Promotion of Engineering Education, American Society for Testing Materials, National Brick Manufacturers Association. Wrote: 'Clays of Ohio and Industries Established upon Them,' *Rep. Ohio Geological Survey*, Vol. V, 1884,' 'The Clay Working Industries of Ohio,' Vol, VII, 1893. Also numerous technical articles and reports. Home: 788 East Broad St., Columbus, Ohio."

The Society, at the last meeting, voted to show its appreciation of Professor Orton's services during the past twenty years. Realizing that mere words are inadequate, we present here the portrait of him to whom we owe so much.

ORIGINAL PAPERS AND DISCUSSIONS.

KAOLIN IN QUEBEC.

By J. Keele, Ottawa, Canada.

Kaolins or residual clays of any kind are rarely found in the Archean upland which comprises so large a portion of the Provinces of Quebec and Ontario. Although feldspar dikes are frequent in this area, they are mostly fresh and unaltered even at the surface and kaolinization or even semi-kaolinization is seldom evident. For these reasons the isolated deposit of kaolin of workable dimensions which occurs at St. Remi is remarkable, and so far as we know at present, is unique in the Province of Quebec. The property is owned by the Canadian China Clay Company and is situated near the village of St. Remi, Amherst Township, Labelle County, about 70 miles northwest of Montreal. It lies a short distance north of the magnesite deposits described by Wilson.[1]

The kaolin occurs in a north and south trending drift covered ridge, about one-half mile in width, which intervenes between higher rocky ridges of granite and syenite gneiss and from which it is separated by well-marked depressions. Wherever the kaolin has been exposed in working and prospecting, the bed-rock that contains it is the Grenville quartzite, in vertical or nearly vertical beds, trending in a northwesterly direction. The main body of kaolin enclosed in the quartzite beds lies along the western slope of the ridge. The quartzite wall rock on the east of the kaolin is mostly massive, but on the west side (Fig. 1) it is shattered and friable for a width of 800 feet. Throughout most of the shattered zone the quartzite is permeated by small stringers or

[1] *Trans. Am. Ceram. Soc.*, **19**, 254–259 (1917).

leads of kaolin, varying from a fraction of an inch to four feet in width. The main body of kaolin has been uncovered in one place continuously for about 1400 feet and has been traced, by test pits and trenches, for at least 7,000 feet. The width varies from an extreme of about 100 feet to less than 20 feet. In a boring, kaolin was encountered to a depth of 150 ft. The covering of glacial drift varies from 2 to 10 feet in thickness.

FIG. 1.

Quartzite wall rock in the kaolin mine at St. Remi, Quebec, showing vertical and horizontal lines of fracture. The overburden is glacial drift.

Most of the known occurrences of kaolin are due to alteration of the rock *in situ*, but the deposit at St. Remi appears to have been deposited in its present position in the quartzite from an extraneous source, the silica of the quartzite having been replaced by kaolin. The surfaces at the planes of faulting and fracture of the quartzite rock have been channelled by the solution of the silica, and kaolin now occupies the channels. There are large masses of mixed quartz grains and kaolin, in the main lead, which still show the original structure of the quartzite

rock. The boundaries of the kaolin are irregular, following the zone of greatest fracturing in the quartzite. Where the quartzite is dense and unbroken there is no kaolin. The quartzite contained so little feldspar originally that less than one per cent. of the kaolin could be accounted for from this source.

There are two other sources of kaolin, the one being the orthoclase in the beds of garnet gneiss included in the quartzite, the other, the batholithic masses of granite and syenite which adjoin the quartzite belt, with occasional dikes of the latter. One of the syenite dikes in the quartzite was partially weathered, the chemical composition being similar to that of cornish stone. The kaolin may have been formed by rising igneous waters acting on the feldspars of he surrounding masses and moving freely in the fractured zone of the quartzite, the presence of tourmaline being one of the evidences of pneumatolytic action.

There are several masses of buff and pink kaolin present in the main lead which may owe their discoloration to the percolation of water through the overlying drift. Over a large part of the deposit, however, a snow-white clay is in direct contact with the drift, so that the discoloration may not be all accounted for in this way. Certain of the beds, included in the quartzite, contain iron-bearing minerals, the decomposition of which probably contributed a portion of the stain.

China Clay.—A washing plant, Fig. 2, was erected and placed in operation in 1912 and washed china clay has been produced since that time. Most of the washed product is supplied to the paper trade, although several carloads have been shipped to potteries in the United States. The capacity of the plant has been increased to meet the greater demand for kaolin during the past few years. The crude material, consisting of a mixture of quartz particles and clay, with a small percentage of finely divided tourmaline, yields, upon washing, about 40 per cent. of china clay. This clay is more plastic and has a greater shrinkage than the English china clays. Its softening point is cone 34. The excellent quality of the washed clay is indicated by its chemical composition: Silica 46.13 per cent., alumina 39.45 per cent., total fluxes 1 per cent., the balance being combined water.

The kaolin first mined from the deposit was uniformly white

but as the mining and stripping progressed southward, a large amount of discolored clay was encountered. This discolored clay contains about 2 per cent. of iron oxide and develops a light red color upon burning and is obviously not included with the whiter material in washing. The discolored material being quite refractory, its utilization in the manufacture of second quality fire brick is proposed and a small plant for this purpose will be erected at the mine during the coming winter. Some portions of the discolored clay contain sufficient quartzite to pro-

FIG. 2.

Kaolin mine and washing plant of the Canadian China Clay Company at St. Remi, Quebec, in 1912.

vide the necessary grog for brick making, without further additions. Additional amounts of quartzite for this purpose are available in the crumbling west wall. The discolored clay when washed is far more plastic than the white, in fact its working qualities are such that it can be thrown on the potters wheel almost as well as a stoneware clay, and may possibly be utilized in the manufacture of novelty pottery. The discolored clay has the open burning qualities of a kaolin, so that if a dense body, maturing at a low temperature is desired, its mixture with a vitrifying clay is necessary.

Silica Products.—The shattered and friable quartzite occurring along the western flank of the deposit is permeated throughout by specks and stringers of kaolin. A washing test of a sample collected over 150 feet, at right angles to the kaolin vein, showed that 11 per cent. passed a 200-mesh screen and that most of this fine material was kaolin. The character of this rock suggested that it might be used in the manufacture of silica brick of the ganister type, by simply milling the rock in a wet pan and moulding it into brick shapes. The preliminary tests for this purpose indicated that the behavior of the quartzite under heating and the character of the bond produced were excellent. There seems to be no doubt that a clay-bonded silica refractory brick, having a wide range of usefulness, may be produced from this material. The amount of raw material available for this purpose is unlimited.

It is proposed to break down the quartzite in dry pans and to subject the ground product to a washing process which will yield a clean quartzite sand, suitable for the manufacture of glass and carborundum. A laboratory test for this purpose demonstrated that most of the wall rock, when crushed, yields a sand of the proper texture, and having the following analysis: Silica 99.25 per cent., alumina 0.06 per cent., iron oxide 0.69 per cent. If a suitable commercial process can be devised for treating the wall rock, the utilization of that part of the deposit for this purpose is most promising.

COMMUNICATED DISCUSSIONS.

H. Ries: The kaolin deposit of St. Remi, described by Mr. Keele, is probably one of the most interesting in North America. As he states, it is exceptional to find kaolin deposits within the glaciated region, as the advance of the continental glacier scraped off practically all residual clay that had formed in pre-glacial times. It is conceivable, of course, that some residual material might have remained because of the fact that it had accumulated in rather narrow pockets, protected on both sides by hard rock. Deposits of this type have been found at Bedford, Mass., and near Cornwall, Conn. The latter resembles the St. Remi material somewhat in being associated with quartzite.

The question of the origin of the St. Remi material, which Mr. Keele raises, is very interesting, but at the same time it is one that is sometimes difficult to decide. This same question has been agitated for years regarding the Cornwall, England, china clays. Were they formed by weathering, or by the action of vapors or heated waters of volcanic origin rising along fractures in the granite?

I had the opportunity of seeing these St. Remi deposits when they were first opened up, but there was then not as much opportunity for studying them as Mr. Keele has since had.

It seems to me that the association of the clay with fracture zones in the quartzite is not necessarily an indication of its deposition by rising waters, for the fracture planes might also have served as a pathway for descending waters. On the other hand, the apparent absence of feldspar in the fresh quartzite might be against the theory that the kaolin had been formed by the weathering of a feldspathic quartzite.

There is, however, it seems to me a third possibility, *viz.*, that pegmatite solutions have invaded the quartzite in an irregular manner and that the weathering of the pegmatite deposited has yielded the kaolin. Until we get deeper into the deposit, definite proof may be lacking. Indeed there has always been some doubt regarding the possibility of kaolin being formed at depth by rising solutions of magmatic origin, a point which has been discussed somewhat at length by W. Lindgren.[1]

R. R. HICE: The occurrence of this deposit is rather unique. The whole region has been so thoroughly glaciated that we naturally expect all products of decay would have disappeared, the time elapsed since the glacial period being too short to give us products of decay in any quantity. I am not personally familiar with this locality, but farther west, where the underlying rock is gneiss, cut by very frequent and often well-develope pegmatite veins, there is no evidence of the weathering of the pegmatite at the surface.

We do know, however, that notwithstanding the intense glaciation which all of this portion of Canada has undergone, in-

[1] "Economic Geology," 10, 89–93 (1915).

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[1] "Economic Geology," **10**, 89–93 (1915).

cluding the removal of all the products of decay, and generally of all the sedimentary rocks which once covered the gneiss now exposed, there are a few occurrences still remaining of the sedimentary rocks which once covered the gneiss to an unknown distance toward the north. It is therefore clear that occasional spots may be found where all of the products of decay have not been eroded and this occurrence at St. Remi is probably one of these few occurrences.

A hurried perusal of Mr. Keele's paper perhaps raises the question as to whether or not this clay should properly be classed as a kaolin, and again emphasizes the fact that the term "kaolin" has been badly abused by a more or less deliberate misapplication of the term, for the purposes of industrial promotion.

SPECIAL POTS FOR THE MELTING OF OPTICAL GLASS.[1]

By A. V. Bleininger, Pittsburgh, Pa.

It was realized at the very initiation of the work on optical glass, begun in the Pittsburgh Laboratory of the Bureau of Standards about three years ago, that the production of suitable pots plays an important part in the manufacture of this type of glass. It is evident that the pot material must resist corrosion by the glasses, some of which are very active in this respect. The solution of the clay body in the glass causes serious difficulty through the production of striae due to disturbance of the homogeneity, resulting in threads or strings which are stirred into the molten mass. It should be stated here, however, that solution of the pot is not the only cause of striae, but that they may be due to lack of homogeneity in the glass itself. Again, it has been observed that the constituent of the pot body first dissolved by the glass is iron oxide. The coloring power of iron, especially with the heavy flint and barium glasses, is very intense, so that very small quantities suffice to impart to the melt a very decided yellow or green shade. This coloration is injurious not only for optical reasons with reference to photographic purposes, but it is a powerful factor in cutting down the light transmission. Since the use of decolorizers is out of the question in optical glass, owing to the high absorption of light caused by them, it is obvious that the content of iron oxide must be kept down by the use of practically pure reagents and by the use of pots as low in this constituent as possible. It is readily seen that, by the use of the ordinary type of pot, the amount of iron brought into the solution might eas ly be several times that of the original iron content of the entire glass batch. The use of even the purest reagents would thus be of no avail.

It would appear that pots used for this purpose should be resistant to corrosion by the molten glass, yet sufficiently refrac-

[1] By permission of the Director, Bureau of Standards.

tory to withstand the high temperature of the furnace, which may approach 1475° C, and the hydrostatic pressure of the liquid charge, and should be as low in iron oxide as possible. Since the pots are used but once, the thickness of the bottom and walls may be cut down to the minimum. Owing to the high value of the glass the cost of the pot, within obvious limits, is not a serious consideration.

The first pot mixture used in this laboratory, when operations were begun on a larger scale, was as follows:

	Per cent.
Laclede-Christy bond clay, 69-B	6
Tennessee ball clay	5
Bond clay from Anna, Ill	7
Kentucky ball clay	5
"Highlands" fire clay, St. Louis	5
N. Carolina or Delaware kaolin	12
Calcined "Highlands" clay, 10-mesh	20
Calcined kaolin, through 16-mesh	40
	100

In using this mixture it is necessary to calcine the kaolin to a temperature of not less than the softening point of cone 14. This, of course, increased the cost of the pots. Later, the calcined kaolin was replaced by a mixture of 80 per cent. kaolin (N. Carolina, Florida and Georgia in equal parts), 10 per cent. flint, and 10 per cent. of feldspar, fired also to cone 14. This gave a sharper and less friable grog. Both compositions gave excellent results with reference to the standing-up qualities and the resistance of the pots to corrosion. Still, the iron content of the mixture was somewhat too high and it was thought desirable to work out a composition akin to that of a hard porcelain. After some experiments the following composition was arrived at:

	Per cent.
Calcine	43
Kaolin	25
Plastic bond clays	25
Feldspar	7
	100

Here, the calcine consisted of the kaolin, feldspar and flint mixture mentioned above. It is evident that in blending such a number of materials great care is necessary in order to secure thorough dry mixing and pugging. These pots likewise gave very satisfactory results.

The question of procuring the calcine in larger quantities was found to be an annoying one and we cast about for a cheaper source of grog. This was found in the waste bisque of white ware potteries, which is obtainable at a reasonable price and in sufficiently large quantities. This type of body corresponds to the general composition of 35 per cent. kaolin, 15 per cent. ball clay, 14 per cent. feldspar, and 36 per cent. flint. The white granite bisque softens at about cone 30 and possesses, on account of the high flint content, excellent standing-up qualities under conditions of pressure at high temperatures. It is evident that porcelain bisque, whether table ware, electrical porcelain, or floor tile, would not answer for this purpose, owing to the low refractoriness. There would be no objection, of course, to the use of this kind of material in replacing the feldspar introduced, the proportions of white ware bisque and porcelain bisque introduced being such as to maintain the desired refractoriness. In employing white ware bisque, it should be obtained in as clean a condition as possible and care should be taken not to produce too large a percentage of fines (finer than 80 mesh) in grinding. If this grog should become too fine, it might cause serious cracking of the pots during cooling, probably at a temperature of about 625° C when the glass is still in a semi-fluid condition. This defect is due to vitrification, facilitated by the presence of the fine particles of grog and the resulting homogeneous porcelain structure. In satisfactory pots, the grains of grog should still retain their identity as shown by their outlines.

At the present time both white ware bisque and old pot shell (from porcelain type pots) are being used and the composition of the pot batch is as follows:

	Per cent.
White ware bisque, through 10-mesh	35
Pot shell, through 10-mesh	10
Feldspar	3
Flint	4
Tennessee ball clay No. 5	15
Illinois bond clay	5
Kaolin	28
	100

The ground and screened grog and other components of the body batch are weighed, mixed, and then tempered in a wet pan. It is desirable, in tempering, that the mullers be raised about $^1/_4$ inch off the bottom of the pan so that the grinding action is reduced to the minimum. The clay is then passed through a vertical pug mill and stored as long as possible. The body should be aged at least a month but under our conditions this has not been possible, owing to the demand for pots. The treading of the plastic body has been done away with as unnecessary. The pots are built up by hand in the usual manner and both the open and covered types are made. The pot used in our laboratory is 34 inches in diameter (outside), 27 inches high, and has a bottom 4 inches thick. The wall tapers from $2^1/_2$ inches (top) to $3^1/_2$ inches (bottom). The weight of each pot is about 500 pounds. After drying for about four weeks, the pots are ready for the furnace.

One or two pots each week are also being made by the casting process. The composition of this body is as follows:

	Per cent.
White ware bisque	48
Plastic bond clay	23
Kaolin	24
Feldspar	5
	100

The slip used carries 80 per cent. of solids and hence 20 per cent. of water. A mixture of equal parts of sodium silicate and sodium carbonate is used as the electrolyte and the amount added, in terms of the dry weight of the body, is 0.20 per cent.

The arrangement of the mold, as shown in the illustration of Fig. 1, needs no detailed description. It is, of course, necessary to hold the core firmly in position by means of cross beams and tie rods as the upward hydrostatic pressure of the slip is very con-

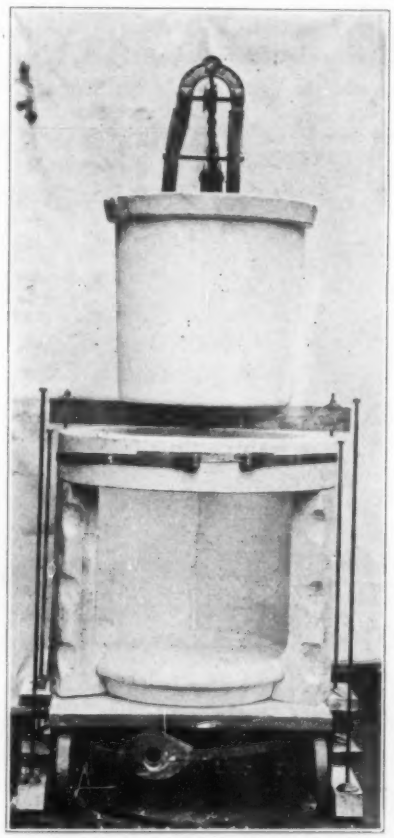

FIG. 1.
Casting mold with core removed.

siderable. The casting, as now practiced, is through three funnels arranged symmetrically around the circumference of the mold. The liquid in the funnels is replenished as the level is lowered. During the last stage of the casting, the settling is

very slow, so that the funnels may be filled and the process allowed to go on without close supervision. Absorption of the liquid ceases after about 16 hours and the core may then be removed. The outer mold may be removed after 24 hours. Suitable hoists are necessary for the handling of the mold parts and the pots.

The process of preparation of the slip is very simple, consisting in introducing the weighed, ground body constituents into a double blunger together with the required amount of water in

FIG. 2.

The first set of porcelain pots made at the Pittsburgh Laboratories, Bureau of Standards.

which the electrolytes have been dissolved. When the desired consistency has been attained, the slip is allowed to run into a large bucket which is conveyed to the mold, hoisted and the slip discharged into the funnels. No difficulty has been experienced in drying the cast pots in less than 3 weeks. They have given very good satisfaction in the glass furnaces and, if anything, are superior to the hand-made ones, especially on account of the fact that they have thinner walls, the thickness

varying from 2 to 3 inches. For this reason less time is required in heating up.

In the use of porcelain type pots it is important to raise the temperature of the furnace to not less than 1400° C before the charge is introduced, in order that the body may become vitrified. The temperature is then lowered and the glass batch is introduced into the pot. Unless this is done, the benefits of the porcelain structure are lost and the pot may corrode as much, or more, than one of the ordinary type.

The same body composition is also used in the casting of the stirring rod parts, which are immersed in the glass during the mixing stage of the melt.

Our experiences with pots for the melting of optical glass have been freely imparted to pot manufacturers and makers of fine glass and, as a result, pots of similar composition are being produced by several firms.

The illustration (Fig. 2) shows the first large porcelain pots made in this laboratory, in the fall of 1917. Small porcelain pots, holding about 30 pounds of glass, were first used by us in May of the same year.

COMMUNICATED DISCUSSIONS.

C. H. KERR: I have been exceedingly interested in reading this paper, my chief thought being one of regret that so few readers have been through the mill so as to have the correct perspective to appreciate the work presented. Nothing, but the actual experience of working on and solving (more or less completely) the problem of making a pot that permits the production of real optical glass, can give one a proper realization of the great difficulties involved. Very few people, even among those who have had some contact with optical matters, realize how absolutely we depend upon optical glass in this great war.

Practically all of the materials used in all industries offer some possibility of substitution. It is frequently difficult, in the use of structural materials, to obtain results by the substitution of materials that are fully equal to the original, but almost always an approximate substitution can be made. This is not true

in the optical glass work. We must have the optical glass for fire control instruments for our Army and Navy and nothing will take its place.

It is very fortunate, although not generally realized by the American people, that we now have an optical glass industry in this country well started and we are able to take care of our military requirements with a very considerable degree of satisfaction. Contrary to usual belief, the production of optical glass is not, at the present time, the limiting feature in the production of optical instruments for fire control purposes.

Throughout the development of the optical glass industry the manufacture of a pot in which it is possible to produce a good grade of optical glass has always been of the first importance and, very frequently, it has been the limiting feature in a particular line of work. For the production of most of the types of optical glass it has been very difficult to secure clays of the requisite purity and composition and which, at the same time, possess the required working properties necessary to the production of full-sized pots satisfactory for use in the usual optical glass procedure. It is not difficult to get the required purity, or the required composition, but to combine therewith the physical properties of the clay or mixture which are necessary, has been exceedingly difficult. Such clays and mixtures, however, have been found and are being used successfully. So far as the question of general composition is concerned, my experience has been somewhat parallel with that cited in the paper and has demonstrated that compositions of the types indicated produce excellent pot batches.

In optical glass pot making it is especially true, as stated in the paper, that an excess of fine material in the grog is a very frequent source of disaster. This trouble is best overcome by a control of the non-plastic part of the mixture to see that it has previously been burned to a sufficiently high temperature, so that, after grinding, the resulting mass is a comparatively coarse material. If the material is too soft it very easily breaks down into a fine powder.

The casting process undoubtedly has a great future, especially in the manufacture of pots of this type. Probably the most

important advantage lies in the fact that a denser structure can be obtained by the casting process. The most important application of this point is in the fact that a mixture of a density such that it is hardly practical for use by the ordinary hand-forming process, can be worked very satisfactorily by the casting process. Along this same line, it is possible to increase the rapidity and safety of the drying process when using cast pots, which has the double advantage of being commercially superior for an ordinary batch and also making commercial a batch which, by the usual process, is hardly capable of commercial handling. Another very great point in favor of the casting is the great increase in homogeneity of the mixture to a degree which is not at all possible by the usual hand-forming method.

E. W. TILLOTSON: Dr. Bleininger has brought out one point that may well be given consideration by all users of glass pots. He states that a pot of the porcelain type, to be efficient, must be burned at a temperature considerably above that of he glass furnace. Such a procedure is rarely or never followed in a glass factory. In fact, the pot arch seldom reaches furnace temperature and the result is incomplete burning, especially of the bottom of the pot.

It would appear that the glass maker should give serious attention to the revision of the construction of the pot arch for the purpose of securing a more even burning of the pot and in order that, by burning at a higher temperature, a pot may acquire its maximum density. Such a procedure may be expected not only to lengthen the life of a pot but also to improve its service as regards corrosion, etc.

C. E. FULTON: Mr. Bleininger has covered the subject very thoroughly and there does not seem to be anything of value which I can add in the form of discussion. We have gone through practically the same experience and while the composition of our optical pot batch is somewhat different from that developed by the Bureau, it is essentially the same type, the chief problem, of course, being to secure a pot with a very dense structure and containing a minimum amount of iron. We contemplate making

some pots following the formula given by Mr. Bleininger, in order to see how they compare with the pots we are now using.

D. W. Ross: A matter of prime importance in connection with this paper is that glass pots made in accordance with the lines therein laid down are today being used in practically all the optical glass plants of the country and are producing the desired results. Thus, a great burden of experimenting has been cleared away from the optical glass manufacturer and the pot manufacturer alike.

The compositions, as given for both fire clay and semi-porcelain pots, should form a foundation from which other branches of the glass industry may work out pots, etc., suitable for their special needs.

C. R. Peregrine: The Society is fortunate in having papers like this by Mr. Bleininger contributed to its Journal.

It would be interesting to know how much corrosion takes place when the pots have been properly preheated, and whether this is greater for the cast pots than for those built up by hand in the usual way.

The policy of the Bureau of Standards, through its Director, which makes its experience available to manufacturers, points toward a new era in which coöperation will do much to place American industries in the front rank.

A. V. Bleininger: I believe there is nothing to be added to the above discussion. The question of Mr. Peregrine is already answered in the text.

THE EFFECT OF GRAVITATION UPON THE DRYING OF CERAMIC WARE.

By Edward W. Washburn, Urbana, Illinois.

That the force of gravitation is able, under certain conditions, to appreciably influence the drying of a mass of clay, was called to the writer's attention as a result of the following experience:

A ball of moist, plastic clay about four inches in diameter was placed on the shelf of an ordinary chemist's desiccator, the lower part of which was filled with water, the idea being to keep the air surrounding the ball of clay moist so that the clay would not dry out on standing overnight. It happened that the clay was left in the desiccator for a month, and at the end of this time it was found to have dried out so completely that it readily broke into pieces when dropped upon the floor. On examination even the central portions of the ball were found to be hard and dry.

At first sight, this behavior seemed rather astonishing, as the ball of clay was standing in an air-tight vessel only three inches above the surface of the water and the air surrounding the clay should, it would seem, have been almost saturated with moisture. In seeking the explanation for this behavior the writer came to the conclusion that the water had been actually drawn out of the clay mass by the attraction of the earth. In other words, the clay must have dried for the same reason that water runs down hill.

In order to test the conclusion that the force of gravitation was responsible for the drying, the experiment was repeated under conditions of more exact control. For this purpose a 10-gram mass of moist clay (containing 30 per cent. of water) was suspended by means of a wire from the bottom of the rubber stopper of a bottle containing a small quantity of water, the height of the clay above the surface of the water being about 6 centimeters. (See Fig. 1*a*.) The bottle and its contents were

then completely immersed in a large body of water so as to insure constant and uniform temperature conditions on all sides of the bottle. From time to time the mass of clay was removed from the bottle and weighed. The experiment was continued for eleven days, during which time the mass of clay continuously lost weight at the rate of about 30 milligrams per day. At the end of the eleventh day the mass of clay had lost a total of 0.304

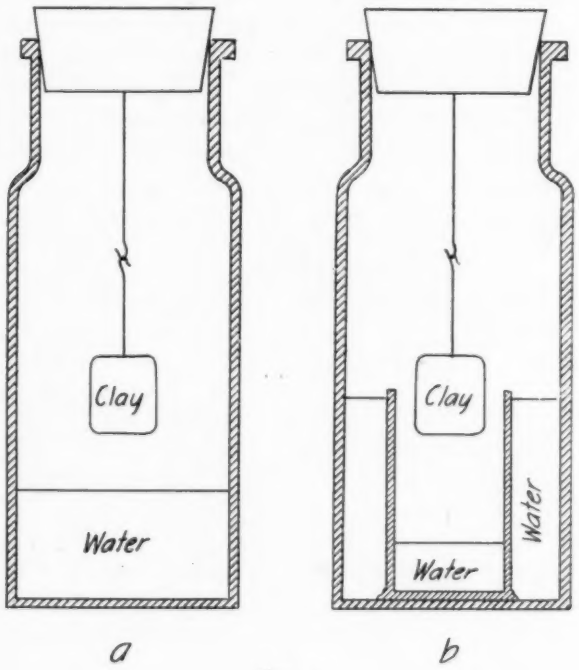

FIG. 1.

gram of water. This water must obviously have distilled out of the clay, under the influence of the attraction of the earth, and condensed into the water in the lower part of the bottle.

To make certain that this was the correct explanation, the mass of clay at the end of the eleventh day was lowered so as to be on the same level as the water in the bottom part of the bottle, but without touching this water, the arrangement being

that shown in Fig. 1*b*. The experiment was then continued and the mass of clay was found to continuously increase in weight, showing that water was now distilling from the liquid water in the bottle, and condensing into the mass of clay. The distillation in this case was, of course, due to the fact that, owing to the presence of small quantities of soluble materials in the clay, the vapor pressure of the water in the clay was lower than that of pure water. The experiment was carried out in duplicate and the two curves showing the variation of the mass of the clay

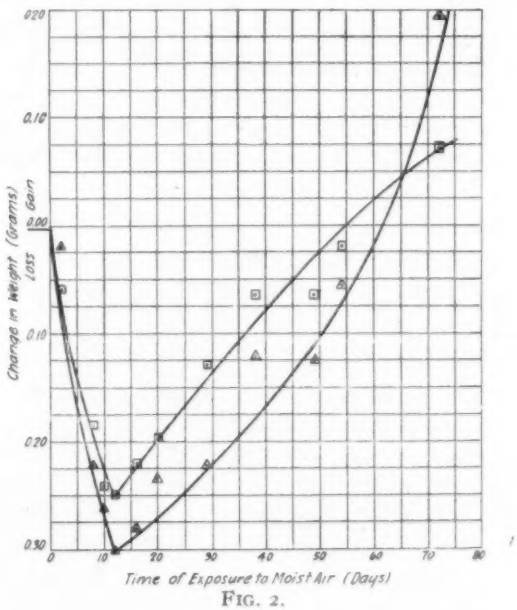

FIG. 2.

from day to day are given in Fig. 2. A repetition of the experiment using a small glass capsule filled with water, in place of the clay cylinder, yielded a similar result.

The only unexpected feature of this experiment was the comparatively great rate at which the water was removed from the clay, under these conditions. Other things being equal, we should expect this rate to be determined by the difference between the vapor pressure of the water in the clay and the partial vapor

pressure of water in the surrounding air. This latter pressure is greatest, of course, at the surface of the liquid water in the bottom of the bottle and decreases steadily with the distance above this surface. The relationship between this latter pressure and the height above the surface of the water is expressed by the equation

$$-dp = gDdh \qquad (1)$$

or for short distances, with sufficient accuracy, by the equation

$$\Delta p = gDh, \qquad (2)$$

where Δp is the difference in the partial pressure of the water at the surface of the liquid water and at the height h above this surface, D is the density of saturated water vapor at the temperature in question and g is the acceleration due to gravity. For a temperature of 20° C and a height of 6 centimeters we find upon calculation that

$\Delta p = 980 \times 17 \times 10^{-6} \times 6 = 0.1$ bar. = about 0.000003 inch of mercury, which is obviously a very small pressure difference.

Aside from the purely theoretical interest which attaches to the above experiment and conclusion, it is perhaps worth while to point out that in order to keep a mass of moist clay from drying, by inclosing it in a chamber containing water, the water should not be placed at a lower level than the mass of clay which is to be kept moist. Moreover, there would appear to be no reason why the force of gravitation should not be made use of in some cases to control the extent and rate of drying of ceramic ware since, at a given temperature, both of these factors are determined by the perpendicular distance between the piece of ware and the bottom of the containing chamber, provided that the air in the chamber is not stirred. Stirring the air would obviously retard the rate of gravity drying but would of course not stop it entirely unless the stirring were 100 per cent. efficient.

It is also interesting to note that since according to Equation 2 the value of p is proportional to D, the density of the saturated vapor, it follows that the rate of gravity drying would increase with the temperature. That is, a mass of moist clay placed in a gravity dryer filled with saturated steam at 100° C would dry

more rapidly than in the same dryer at o° C, although at the latter temperature the air in the dryer would contain very little moisture. In other words, the rate of drying in a gravity dryer is determined by the vapor-pressure *gradient* in the dryer and not by the dryness of the air in the dryer. Indeed, as we have seen, the more moisture the air of such a dryer contains, the more rapid will the drying be, a conclusion which at first sight appears paradoxical.

In this connection attention may also be called to the fact that, in operating a moist closet for storing prepared clay, the drying action of gravity upon this clay cannot be eliminated by hanging wet cloths along the sides of the closet, provided the action of capillarity is depended upon to keep these cloths wet; that is, provided they are supposed to be kept moist by having the lower ends dipping into water in the bottom of the closet. It is true that in such a manner the water placed in the lower part of such a closet may be lifted to the same level as the clay, but such water (*i. e.*, water held up by capillary force acting against gravity) will be under tension and the effect of tension upon a liquid is always to lower its vapor pressure. In fact the vapor pressure at the surface of the meniscus in a capillary tube (in which equilibrium has been established between gravity and surface tension) will be identical with the vapor pressure at the surface of the water outside of the capillary tube, although this latter surface will be at a lower level than the surface inside the capillary. This statement will be true regardless of the size of the capillary; that is, regardless of how great the difference in the two levels inside and outside may be.

Although not bearing directly upon the subject of this paper, it is perhaps worth while pointing out in this connection that a method for the direct measurement of the osmotic pressure of any very dilute solution may be based upon Equation 1. The method requires no membrane of any kind and consists simply in finding, by experiment, at what height above the surface of the pure solvent a small quantity of the solution must be placed in order that it shall neither gain nor lose weight by gravity distillation. This height is identical with the height of the osmotic

column, as can be readily demonstrated by purely thermodynamic reasoning. The method would, of course, in practice, be restricted to solutions of such dilution that the height of the osmotic column would not be inconveniently great. It seems quite within the bounds of possibility that an accurate technique could be worked out for applying this method, which would have many obvious advantages over the other colligative property methods in the case of very dilute solutions.

In addition to the cases discussed above it seems probable that the influence of gravity upon vapor pressure also plays an important part in some of the phenomena connected with the swelling of colloidal gels. Thus it has been observed[1] that if a gel, which has been soaked in water until the swelling has reached its maximum, be then raised out of the water, the gel loses most of its water and consequently shrinks greatly in volume. The water lost in this way must evidently have distilled out of the gel under the influence of some force acting upon the water in the pores of the gel but not upon the liquid water below it. In view of the experiments recorded in this paper, it seems highly probable that the force of gravitation is responsible for this behavior. It is also probable that some experimental results obtained by Foote[2] are likewise the result of the influence of gravitation.

DISCUSSION.

PROF. WATTS: I would like to ask Dr. Washburn if the two clays were the same or different clays.

DR. WASHBURN: The same clay.

PROF. WATTS: Have experiments been conducted to show the difference in the rates at which very dense or open clays

[1] Schroeder, *Proc. Amsterdam Acad.*, **15**, 1078 (1913); **17**, 92 (1914). The so-called Schroeder's paradox was further studied by Wolff and Buchner (*Z. physik. Chem.*, **89**, 271 (1912)) who found, when precautions were taken to conduct the experiment so that gravitation could not act differently upon the water and upon the swollen jel, that under these conditions no difference between the vapor pressures of the two could be detected.

[2] Foote, *J. Am. Chem. Soc.*, **30**, 1390 (1908).

would dry? Do you consider the rate of drying a matter of the size of grain of the clay?

DR. WASHBURN: You can make the rate anything you like by regulating the height at which you place the clay above the water.

PROF. WATTS: This subject brings to my mind a very interesting point in connection with the potter's wet closet. The cup maker has a room in which he keeps his cups subject to jiggering and prior to turning them, the cups remaining in the closet almost indefinitely. They are placed in the closet as soon as removed from the mold and remain until ready for turning. The closet is an ordinary closed chamber, having a large pail of water at the bottom. It is significant that the cups may remain in the closet for a week or ten days, or even longer, before being turned, and yet they appear to be in satisfactory shape for turning and I do not know of any particular reason why the moisture should remain in those cups, unless there is some circulation of the air in the closet. The cup closets are usually chambers built in the side of a large, open room which is normally warmer near the ceiling than near the floor. We may presume that the increased temperature at the top of the room, outside the chamber, develops a warmer zone inside the chamber and maintains circulation of moist air inside the chamber, keeping the cups moist. A potter, in reading this paper of Dr. Washburn's, would immediately raise this question and I believe that my explanation is correct.

MR. LINBARGER: We have conducted a number of experiments on humidity drying systems and find that, when using as high a relative humidity as 90 per cent. when the air in the dryer was not in motion, we get a loss in weight of the material in the dryer. This loss takes place at a definite rate, for when we place the material on an accurately calibrated balance and take frequent readings from the outside, so as not to disturb the air in the dryer, we are able to measure the rate of evaporation. We note, in this connection, that with all other conditions constant, we have more evaporation when we are using a 90

per cent. relative humidity than when the relative humidity is 65 per cent. We have been at a loss to account for this phenomena, but I think Dr. Washburn's paper presents a very satisfactory explanation.

MR. RIDDLE: I would like to ask Prof. Watts if the same conditions are noted in case the walls and shelves of the drying closets are covered with plaster which is kept in a moistened condition? Would the use of plaster materially alter the moisture conditions in the closet?

PROF. WATTS: I was referring to the ordinary wooden construction for the closets. I was not referring to closets having plaster coated walls or shelves.

MR. RIDDLE: I would like to ask Dr. Washburn: under high humidity conditions, is any of the drying due to capillary action? For example, in a tunnel dryer for brick, if the humidity is decreased too rapidly, the flow of moisture from the inside to the outside of the ware is broken.

DR. WASHBURN: In the dryer I speak of, the drying is all due to gravity. The water in the clay gets to the outside by capillary forces to a great extent, but the drying itself is due to gravity. Mr. Watts did not state that the cups did not dry, that is they were not weighed. This action, of course, is a comparatively small one and I think if those cups were weighed, they would have been found to have actually lost water; they might not have lost enough but that they could be turned satisfactorily but they actually would lose water if the air were not stirred.

MR. BARRINGER: I think this paper touches upon fundamental questions in connection with drying, and in discussing them we should be very careful not to lose sight of the proper relation of the various factors affecting drying. One of the gentlemen spoke of "humidity bringing about quick drying or the loss of moisture." Undoubtedly, the high humidity was applied with a certain temperature, and it is practically impossible in drying to separate the various elements concerned.

As I understand it, the theory of drying involves controlling the relation of the vapor pressure of the water in the ware and the pressure of the vapor of the air, outside the ware. There are factors affecting both of these. For instance, the vapor pressure of the water in the ware increases as the temperature, and the pressure of the vapor outside (the moist air) increases as the humidity. The first step in drying is to balance these pressures. There is another factor that must be considered in drying, and that is, the heat conductivity of the clay wares themselves. Very often when we speak of high temperature, we do not mean the temperature of the clay ware itself, but the temperature of the air.

It seems to me that this element of the mechanical motion of the water ought to be considered in connection with the theory of drying and the fundamental considerations I have mentioned. I would like to ask Dr. Washburn whether, under this drying by gravity, he would classify centrifugal force? Suppose you should rotate a piece very rapidly; would the water not tend to leave the clay upon the same principle as by gravity?

DR. WASHBURN: The rotation would tend to increase the pressure of the water on the periphery; an increase of pressure on a liquid always increases the vapor pressure of that liquid.

MR. DAVENPORT: I would like to ask Dr. Washburn if he had an increasing concentration of moisture in the lower portion of the sample?

DR. WASHBURN: No, the sample was very small, I did not attempt to detect it, but of course the upper part must have dried faster than the lower part.

PROF. WATTS: I would like to ask Dr. Washburn if the mechanical operation of removing this piece from the atmosphere in the bottle, and weighing, could have had any material effect as regards the evaporation of the moisture that might have been carried to the surface of the piece?

DR. WASHBURN: In answer to Mr. Watts' question, I will say no, not as far as the correctness of the final result is concerned;

the effects he mentions would merely produce slight irregularities in the points along the curves, but when the clay was lowered to the surface of the water and began to increase in weight, it showed that the effect you mentioned could not have vitiated the conclusions in any way.

TEST OF A PRODUCER GAS-FIRED PERIODIC KILN.[1]

By C. B. Harrop, Columbus, Ohio.

I. Introduction.

The use of producer gas in connection with continuous ceramic kilns has undoubtedly passed through the purely experimental stage. Suggestions that producer gas be used in individual periodic kilns was at first looked upon with considerable suspicion and doubt and some of our recognized engineers even stated freely that the plan was not practical, offering as their reason the belief that producer gas, being a comparatively lean gas and low in calorific value, could not be used for high temperature work, except that hot air be used to support combustion.

One of the first practical attempts to use producer gas, in connection with periodic kilns, was made at the plant of the U. S. Brick Company, at Tell City, Indiana, where a system was installed in 1914. This plant is operating continuously and from a commercial standpoint, the installation has proven entirely satisfactory to the owners. Other plants have since been put into operation, not always successful in every particular, but at least proving that with suitable coal, properly selected and installed equipment and intelligent management, the plan is practical for wares requiring temperatures of 1150° C or lower. To how much higher temperatures it would be practicable to go, tests made so far throw no definite light.

II. The Installation.

(*a*) **Producer.**—The producer is of the round, stationary pressure type, with a double system of blast piping, delivering steam and air to the bosh as well as to the center tuyère (Fig. 1). The inside diameter of the producer is 10′ 6″ and it has a maximum gasification rate of 1250 lbs. of coal per hour. The steam is supplied by the main boiler plant of the factory and is carried at 25 lbs. (gage pressure) at the blower.

[1] By permission of the Director, Bureau of Standards.

(*b*) **Fuel.**—The fuel used was an Indiana coal known as "Washed No. 3 Ayrshire Nut" and was charged at intervals averaging 25 minutes throughout the test.

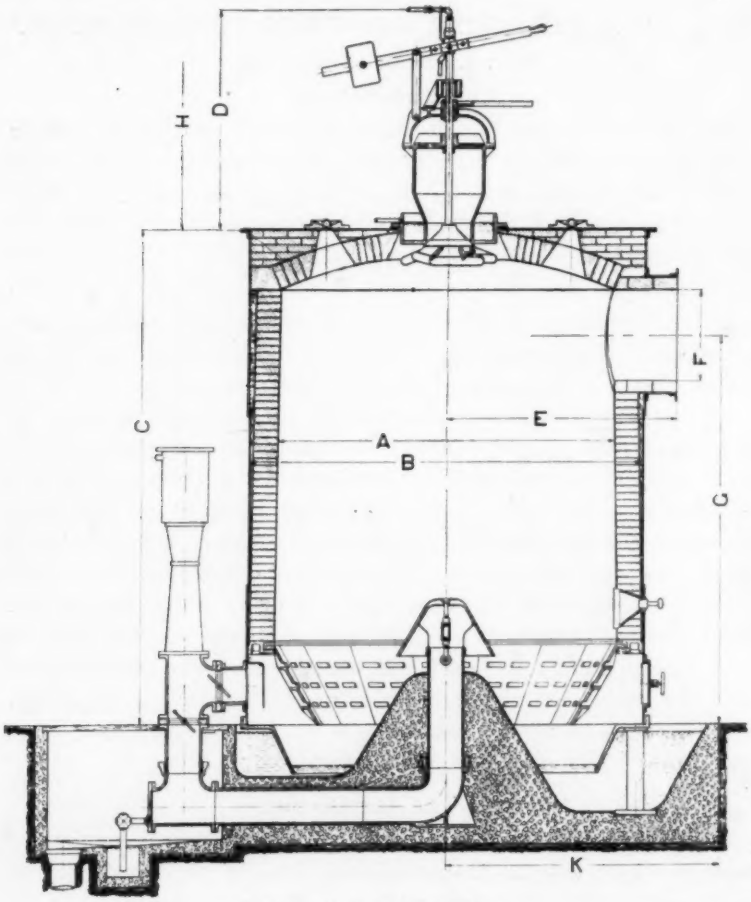

FIG. 1.—Gas Producer.

Each charge of coal was sampled and two combined samples were retained for examination, one covering each half of the period of the test. The two analyses were averaged on the basis of the relative amounts of coal charged during the two halves,

these amounts being indicated in Fig. 2, together with the heating values. The average ultimate analysis was as follows:

Hydrogen	6.10
Carbon	66.31
Nitrogen	1.52
Oxygen	20.59
Sulphur	0.90
Ash	4.58
	100.00

(*c*) **Gas Flues.**—The main gas flue leading from the producer toward the kilns is of brick, with arched top. Its original size was 5′ wide by 5′ high, but it was found that at the place where

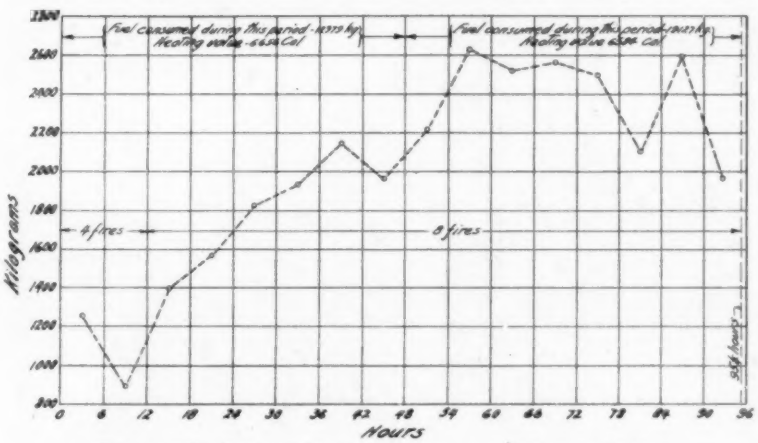

FIG. 2.—Fuel charged into producer over 6-hour periods.

the gas samples were taken, the flue was only 4′ deep, evidently due to a deposit of tar and soot in the bottom. There is a thin layer of sand and about 12″ of earth fill on top of this main flue.

Two branch flues, 24″ wide by 26″ high, partly encircle the kiln under test. The burners are connected with these branch flues by laterals consisting of 10″ sewer pipe, as indicated in Fig. 3.

(*d*) **Air Supply.**—Air for combustion is supplied by a No. 9 top angular discharge centrifugal blower, manufactured by the National Blower Company, of Milwaukee, Wis. This blower is

installed in an isolated building and is belt-driven from a line shaft, which in turn, is driven from a 7″ × 12″ slide valve throttling engine. The speed of the blower was 845 r. p. m. at the beginning of the test and was finally increased to 1065 r. p. m.

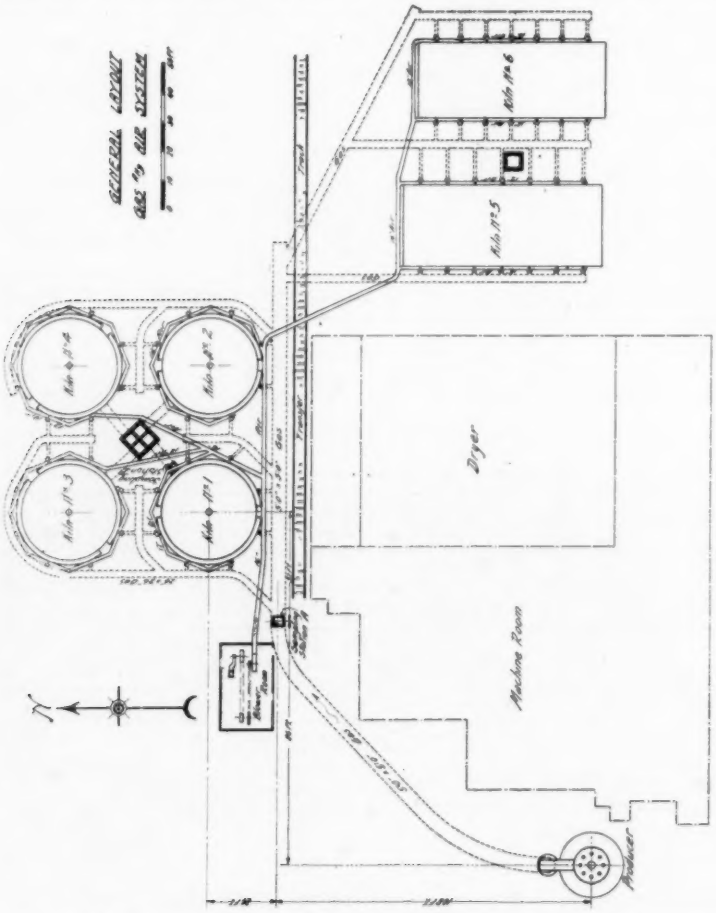

FIG. 3.—Plan of Plant.

(*e*) **Air Ducts.**—The air blower discharges into an overhead metal pipe of No. 22 gauge steel, 16″ in diameter. From this pipe a branch or bustle pipe, 12″ in diameter, practically encircles the kiln about on a level with the top of the kiln wall. Con-

necting each burner with this bustle pipe is a 4″ diameter downtake fitted with a slide damper.

(*f*) **Kiln.**—The kiln used for this test, which is of the round down draft type (Fig. 4) and designated as No. 1, is the nearest one to the producer. This was not according to design, but it happened to be the kiln set at the time that the Bureau representatives were free to carry on the test.

This kiln is 30′ in diameter, is 7′ from the floor to the spring of crown and the crown has a 7′ rise. The crown is 12″ thick and

FIG. 4.—The kiln.

the side wall 22″ thick. The hob is 36″ thick and stands about 30″ high above the ground. There are eight furnaces provided with rectangular bags, 18″ × 30″ inside and 5′ 3″ high. The kiln has two doors, each 4′ wide by 5′ 6″ high.

The floor of the kiln is perforated over its entire area and is served by the rather common cross-head-flue draft collecting system.

The main draft flue, the top of which is about 2′ below the ground line, is 36″ square inside and leads to a 4-compartment chimney, 40′ high, situated about 10′ from the kiln. Each compartment of the chimney is 36″ square and serves but one kiln.

The cast iron burners (Fig. 5) which are of a patented design, are supplied from the underground flues with gas, which passes directly into the central chamber of the burner. For regulating

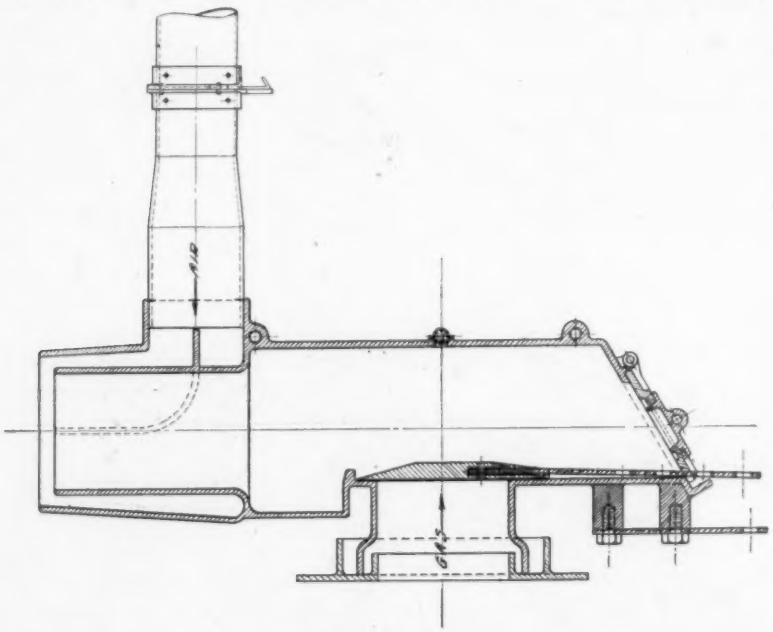

FIG. 5.—Gas Burner.

the gas, there is supplied a flat sliding damper, resting on the bottom of the central chamber, and with a handle for adjusting, which passes through the hinged outer end of the burner. The air for combustion, coming through the downtake, enters an annular space ahead of the gas inlet and surrounding the central chamber, the gas and air not mixing until they leave the inner end of the burner.

The underside of the furnace arch, in the main wall, rises 4″

above the top of the kiln hob, thus leaving an opening 4″ high by about 15″ long into the furnace chamber.

The kiln is started with four fires only, which continue for the first 12 hours and one full size brick is laid across each of the openings above the hob. At the end of the first 12 hours, the remaining four burners are lighted. In 18 hours after starting two bricks are laid across the openings above the hob and in 30 hours these openings are daubed up tight.

(*g*) **Ware.**—The product of this plant is common building brick and face brick of the rough or texture variety, the stiff-mud process being employed for both. The raw material is a rather sandy alluvial clay from the immediate vicinity, bordering the Ohio River. This clay, under oxidizing conditions, burns to a deep red color at about cone 02 in the bottom of the kiln. Under reducing conditions, however, the color passes through various shades of tan, brown and finally to gun metal.

Three courses of common (smooth) bricks are set on edge on the bottom and one course on the flat. On top of these are 44 courses of face brick set flat, making a height in the center of the kiln of about 10′, unburned. The setting is 3 on 2, in 2-brick benches.

Three and a half to four days is the usual time required to burn one of these kilns. The method followed is to increase the temperature to about 995° C (as indicated by an electric pyrometer, the couple of which hangs through the center of the crown) and then to soak for 24 hours at a slowly increasing temperature. While pyrometric cones are placed in the setting near the wicket, the time of finishing is determined by measuring the settle through the center of the crown. The first settle measurement is taken at about 72 hours and the gas is shut off as soon as the settle totals 11 inches.

III. The Investigation.

(*a*) **Object.**—Considering the doubt as to the feasibility of this method of burning clay wares that has existed in the minds of many who have been interested in the reduction of kiln burning expense and labor, it was believed that an investigation of the system would show whether or not it embraced any real points of merit.

When compared with results of similar tests made on solid-fuel-fired, natural gas-fired or oil-fired kilns, and taking labor into account, it can be seen wherein and to what amount, one has an advantage over the other.

It was not desired to make a test of the particular producer in use, but as the producer is a part of the system, it was necessary that the investigation include both producer and kiln. In analyzing the results, we can consider the system as a whole, or, we can consider merely the kiln as being supplied with gaseous fuel of a certain composition and at a certain temperature, and study its performance under the existing conditions.

(*b*) **Apparatus.**—A Hygrodeik was used for determining the temperature and humidity of the atmosphere.

A platform scale was used for weighing the coal charged.

A train, consisting of a water-jacketed glass tube and an asbestos packed glass filter,[1] was used for sampling the tar and soot from the main gas flue. The gas carrying these ingredients was drawn through the train into a water aspirator bottle. The drawing out of the water from this bottle, between two marked levels, indicated the amount of gas drawn through the train. A thermometer was inserted in the aspirator bottle, the readings of which permitted a correction of volume to a basis of the temperature in the gas main.

For determining the water vapor in the producer gas in the main flue, a glass tube $^1/_2''$ inside diameter by 18″ long was used. This tube was filled three-fourths full of calcium chloride and in the remaining space was placed phosphorus pentoxide. Known quantities of gas were drawn through this tube (passing through the calcium chloride first) in the same manner as in sampling the tar and soot.

An iron pipe sampling tube, having small holes at 4″ centers, was used for sampling the producer gas over the entire depth of the main. Gas was drawn continuously from this sampler through a bubble bottle by a water aspirator. A 6-lb. glass sample bottle was used for drawing off samples of gas for analysis, just before passing through the bubble bottle.

A Williams apparatus was used for the analysis of the pro-

[1] *Bur. Mines Tech. Paper*, **137**, p. 20.

ducer gas. This was equipped for the determination of methane and hydrogen by the explosion method.

An iron-constantan thermocouple was used in the main gas flue for determining the temperature.

Two platinum platinum-rhodium thermocouples were used to determine kiln temperature. One of these couples was placed in each kiln door, 4′ above the floor, and extended 6″ into the setting. The doors were closed by double 8″ brick casings, with a 2″ air space between.

An incline-tube draft gage was used for measuring the static draft in the main draft flue.

A sampling device, similar to that used for the producer gas, was employed for the flue gases.

An Orsat apparatus was used for the analysis of all of the flue gas samples.

An iron-constantan thermocouple, for determining the flue gas temperatures, was inserted in the draft flue beside the sampling tube.

A Leeds and Northrup thermocouple-potentiometer, located at a central station, was used in connection with all thermocouples.

(*c*) **Procedure.**—Atmospheric temperature and humidity readings were taken every three hours.

Each charge of coal was weighed and a sample placed in a sealed jar. A record of the coal charged during that period was made each 6 hours. The samples of all coal charged during the first half of the test were combined into a single sample and samples covering the second half combined into a second sample. Proximate and ultimate analyses of these samples were made and their heating values determined.

The crown of the main gas flue was uncovered about 3′ west of the first branch flue leading to the kiln under test. This point is designated (Fig. 3) as "Sampling Station A" and all temperatures and samples of producer gas were taken at this location.

2500 cc. (cool) producer gas were drawn through the tar and soot train every two hours and the temperature of this cooled gas, so drawn into the aspirator bottle, was recorded.

The same procedure as above was followed in connection with the moisture tube.

Analyses were made of producer gas samples covering periods of 6 hours, equal portions of the sample being drawn into the bottle every two hours. Analyses were made as soon as possible after the samples were completed.

Temperature (potentiometer) readings were taken every 2 hours, covering the producer gas in the main flue; kiln (at both doors), and the flue gases in the main draft flue. Thermometer readings at the cold junctions of all thermocouples were taken at the same time.

The crown of the main draft flue was uncovered just outside of the kiln hob, this point being designated (Fig. 3) as "Sampling Station B," and all temperatures, draft readings and samples of flue gases were taken at this location.

Draft gage readings were taken every two hours (Fig. 6).

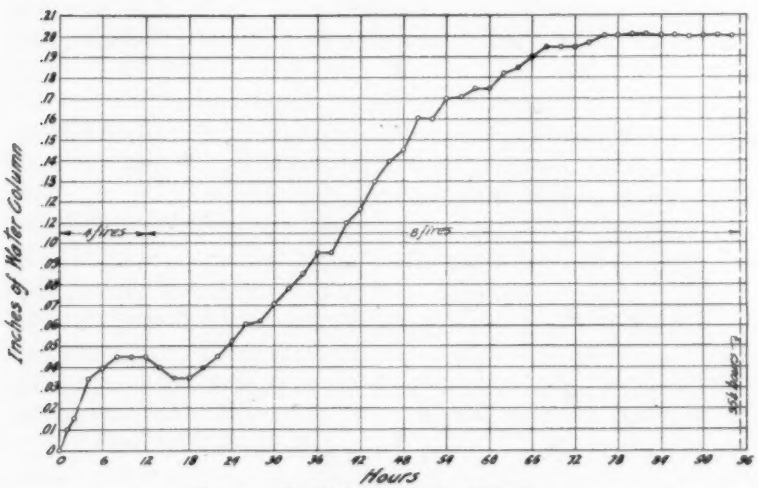

FIG. 6.—Draft in the main draft flue.

Flue gas samples were taken in the same manner as the producer gas samples and the analyses were made as promptly as possible.

Barometric pressure readings were secured from the nearest U. S. Weather Bureau Stations.

IV. The Test.

The handling of the burn was normal in all respects.

The kiln under test was burned for "reds" and contained 9522 smooth brick in the bottom, weighing 5.443 lbs. each, and 62,184 texture brick above, weighing 5.385 lbs. each.

The fires were started at 6 P.M. and burned for $95^1/_4$ hours. The kiln which was being burned just prior to the test was cut off at 2.30 P.M. and the producer remained idle until 6 P.M. Although instructions were given to maintain the fuel level in the producer until the kiln to be tested was started, this was not done, with the result that the first six hours of the test showed a somewhat greater fuel consumption than would otherwise have been necessary and, of course, this extra fuel was charged against the test. However, this was not a serious matter and does not greatly affect the figures.

The first settle measurement was taken after 71 hours and showed 4″. The further progress of the settle is indicated in Fig. 9.

At 62 hours the static pressure of the gas at the burners was 0.14″, water gage, and the air pressure, 0.95″. At 72 hours the pressure of the gas in the gas main at "Sampling Station A" was 0.12″.

CALCULATIONS.

1. Heat from the Coal Fired.—The total amount of coal supplied to the producer during the test was 32,106 kg.

During the first half of the test, 12,979 kg. of coal was used, the average heating value being 6656 Cal. During the last half 19,127 kg. was used, the average heating value being 6584 Cal.

12,979 × 6656 = 86,388,224 Cal.
19,127 × 6584 = 125,932,168 "

212,320,392 Cal. = total heat possible from the coal fired.

2. Volume of Dry Producer Gas.—The proximate analysis of the moisture free ash was

	Per cent.
Volatile matter	1.10
Fixed carbon	3.08
Ash	95.82
	100.00

As the coal contained 4.58 per cent. ash

$32{,}106 \times 0.0458 = 1470$ kg. pure ash in the coal.

Then $\frac{1470}{0.9582} = 1533$ kg. ash from the coal supplied.

$1533 \times 0.0308 = 47.2$ kg. fixed carbon in the ash.

The main draft flue is said to fill up with tar and soot at the rate of 12″ in depth per year. The length of the main flue from the producer to "Sampling Station A" was 130 ft. and the width of the flue 5 ft. Therefore, the amount of tar and soot deposited throughout this length of flue during the four day test can be approximated as follows:

$$130 \times 5 \times \frac{4}{365} = 7.12 \text{ cu. ft.}$$

This material had a bulk specific gravity of 1.33.

$\therefore 7.12 \times 62.4 \times 1.33 = 591$ lbs. or 268 kg. of tar and soot.

As about 93 per cent. of this is carbon, there occurred during the test, a deposition between the producer and the sampling station of 249 kg. of carbon.

As the total coal used was 32,106 kg.

$32{,}106 \times 0.6631 = 21{,}289$ kg. of carbon in the coal fired.

$21{,}289 - (47 + 249) = 20{,}993$ kg. of carbon passing the sampling station in gaseous form and suspended in the gas as soot and tar.

There was an average of 7.56 g. of tar in each cu. m. of producer gas at the average flue temperature of 580° C. This is equivalent to 23.6 g. of tar in each cu. m. of producer gas at 0° C or 0.526 g. of tar in each gram-molecular volume of producer gas at 0° C. The results of a number of determinations have shown that producer tar contains approximately 90 per cent. carbon.

$\therefore 0.526 \times 0.90 = 0.4724$ g. of carbon per gram-molecular volume of producer gas at 0° C.

There was an average of 3.47 g. of soot in each cu. m. of producer gas at the average flue temperature of 580° C. This is equivalent to 10.85 g. of soot in each cu. m. of producer gas at 0° C, or 0.242 g. of soot in each gram-molecular volume at 0° C.

The total carbon from tar and soot per gram-molecular volume of producer gas at 0° C was 0.4724 + 0.242 = 0.7144 g.

The average of the analyses of the producer gas[2] samples shows:

7.12 per cent	CO_2
21.85 per cent	CO
3.25 per cent	CH_4
32.22 per cent. carbon-bearing gases.	

TABLE 1.—ANALYSES OF PRODUCER GAS.

Sample	A.	B.	B.[1]	C.	D.	E.
CO_2	10.31	10.51	8.94	8.70	7.50	7.30
O_2	0.80	0.60	2.15	0.30	1.60	0.30
CO	14.43	13.71	15.69	19.60	17.40	19.20
CH_4	10.41	7.51	2.73	5.23	4.90	6.83
H_2	8.93	12.36	15.38	12.70	11.41	10.44
N_2	55.12	55.31	55.11	53.47	57.19	55.93

Sample	F.	G	H.	I.	J.	J.[1]	K.
CO_2	6.90	7.60	7.60	7.00	8.00	7.78	6.90
O_2	0.20	0.60	0.30	0.50	0.30	0.00	0.20
CO	24.30	20.10	18.30	21.50	18.50	20.01	19.70
CH_4	8.70	8.60	8.36	5.21	6.83	4.24	8.30
H_2	7.18	8.93	7.53	11.98	10.09	13.42	8.79
N_2	52.72	54.17	57.91	53.81	56.28	54.55	56.11

Sample	L.	M.	N.	O.	O.[1]	P.
CO_2	6.90	7.00	7.10	7.20	7.04	7.70
O_2	0.90	0.10	0.00	0.20	0.23	0.20
CO	20.10	19.40	17.80	16.90	21.50	20.60
CH_4	8.17	8.33	8.64	9.85	3.32	7.15
H_2	8.65	9.48	9.01	6.53	13.16	8.33
N_2	55.28	55.69	57.45	59.29	54.75	56.02

[1] Check analyses by the U. S. Bureau of Mines.

[2] Table I shows the analyses of the producer gas made at the time of the test. Three of these samples were sent to the Bureau of Mines Laboratories for exact analyees and these also are shown. As stated before, the field

0.3222 × 12 = 3.8664 g. = weight of carbon in the carbon-bearing gases in one gram-molecular volume.

3.8664 + 0.7144 = 4.5808 g. total carbon in the producer gas per gram-molecular volume.

Then $\frac{20,993,000}{4.5808}$ = 4,582,824 gram-molecular volumes of dry producer gas,

or $\frac{4,582,824 \times 22.3}{1000}$ = 102,197 cu. m. dry producer gas at 0° C,

or $\frac{102,197}{273} = \frac{x}{273 + 580}$.

x = 319,319 cu. m. dry producer gas at 580° C, passing "Sampling Station A" during the test.

3. Weight of Dry Producer Gas.—From the average analyses of the producer gas

		Per cent.
CO_2	0.0712 × 44 = 3.1328	= 12.41
O_2	0.0092 × 32 = 0.2944	= 1.17
CO	0.2185 × 28 = 6.1180	= 24.24
CH_4	0.0325 × 16 = 0.5200	= 2.06
H_2	0.1365 × 2 = 0.2730	= 1.08
N_2	0.5321 × 28 = 14.8988	= 59.04
		100.00

25.2370 g. weight of one gram-molecular volume.

analyses were made with a Williams apparatus, using the explosion method for determining hydrogen and methane. It is acknowledged that this method is not reliable and a comparison of the analyses in this case shows that the Williams apparatus gives high methane and low hydrogen in each instance. Furthermore, this apparatus is not suitable for gases with high CO content and further comparison of the analyses will show that the Williams apparatus failed to indicate the full amount of CO present. In view of these errors, it was decided to adjust the field analyses to correspond to the exact analyses made in the laboratory, in the following manner: The field analyses of the three samples, sent to the Bureau of Mines, were averaged, as were also the analyses of the same samples made in the laboratory. The average of all the field analyses was then adjusted in accordance with the relation between the average of the three analyses made in the field and those made in the laboratory.

$\frac{4{,}582{,}824 \times 25.237}{1000} = 115{,}657$ kg. = total weight of the dry producer gas.

4. Free Hydrogen and Hydrogen in Methane in the Producer Gas.—

$115{,}657 \times 0.0108 = 1249.1$ kg. = free hydrogen.

$115{,}657 \times 0.0206 \times {}^1/_4 = 595.6$ kg. = hydrogen in methane.

1844.7 kg. = total

5. Hydrogen in the Water Vapor of the Producer Gas.—There was an average of 7.85 g. of water vapor accompanying each cu. m. of dry producer gas at the average flue temperature of 580° C.

$\therefore 319{,}319 \times 0.00785 = 2{,}506$ kg. of water vapor in the producer gas or $2{,}506 \times {}^1/_9 = 278.5$ kg. = hydrogen in the water vapor of the producer gas.

6. Hydrogen in the Water Vapor Entering the Producer with the Air.—$4{,}582{,}824 \times 0.5321 = 2{,}438{,}521$ gram-molecular volumes of nitrogen in the producer gas at 0° C.

$32{,}106 \times 0.0152 = 488$ kg. = nitrogen in the coal fired.

$\frac{488{,}000}{28} = 17{,}425$ gram-molecular volumes of nitrogen at 0° C from the coal.

$2{,}438{,}521 - 17{,}425 = 2{,}421{,}096$ gram-molecular volumes of nitrogen at 0° C from the air.

$\frac{2{,}421{,}096}{0.792} = 3{,}056{,}939$ gram-molecular volumes of dry air.

$\frac{3{,}056{,}939 \times 22.3}{1{,}000} = 68{,}170$ cu. m. of dry air, at 0° C, entering the producer.

$\frac{68{,}170}{273} = \frac{x}{273 + 24}$.

$x = 74{,}163$ cu. m. dry air at atmospheric temperature (24° C).

The vapor pressure of completely saturated atmosphere at 24° C is 22 mm. of mercury.

The average relative humidity during the test was 75.2 per cent. (Fig. 7).

The average partial pressure of the atmosphere, due to the moisture, was $22 \times 0.752 = 16.54$ mm. mercury.

The average barometric pressure during the test was 756 mm. mercury.

$756 - 16.54 = 739.46$ mm.

$74{,}163 \times \frac{756}{739.46} = 75{,}822$ cu. m. of moist atmosphere at 24° C.

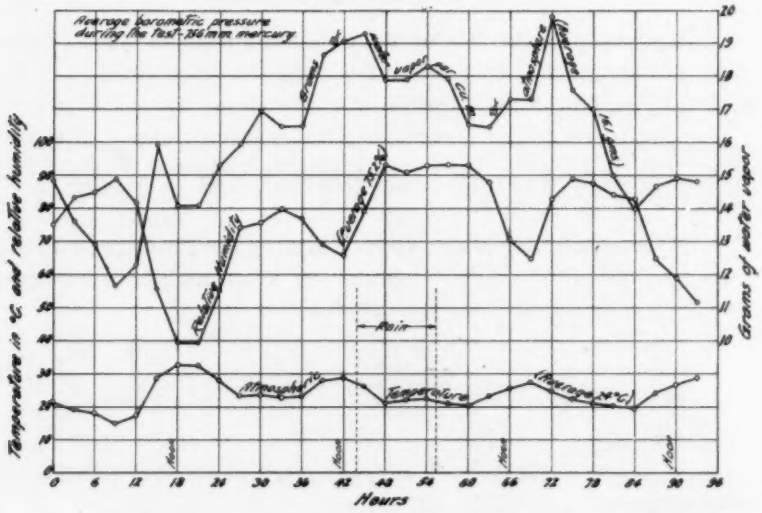
Average barometric pressure during the test-756 mm. mercury
Grams of water vapor per cu. m. of atmosphere (average 16.1 grms)
Relative Humidity (average 75.1%)
Atmosphere Temperature (average 24°C)
Rain
Hours
Temperature in °C. and relative humidity
Grams of water vapor

FIG. 7.—Temperature and Humidity of the Atmosphere.

During the test there was present an average of 16.1 g. of water vapor per cu. m. of atmosphere at 24° C.

$\therefore \frac{75{,}822 \times 16.1}{1{,}000} = 1221$ kg. of water vapor entering the producer with the air, or

$1221 \times \frac{1}{9} = 135.7$ kg. of hydrogen.

7. Hydrogen in the Tar Carried in the Producer Gas.—If the producer tar contained 90 per cent. carbon, its hydrogen content was 10 per cent.

$$\frac{4{,}582{,}824 \times 0.526 \times 0.10}{1{,}000} = 241 \text{ kg. of hydrogen in the tar.}$$

8. Total Hydrogen in the Producer Gas.—The total amount of producer gas, passing "Sampling Station A" during the test, contained the following hydrogen:

As-free hydrogen	1249.1 kg.
In the methane	595.6 kg.
In the water vapor	278.5 kg.
In the tar carried in the gas	241.0 kg.
	2364.2 kg.

9. Hydrogen from the Steam Supplied to the Producer.—Of the tar and soot deposited in the gas flue during the test, about 7 per cent. was hydrogen or, $268 \times 0.07 = 19$ kg. of hydrogen.

There was contained in the coal

$32{,}106 \times 0.061 = 1958.5$ kg. hydrogen.

The hydrogen passing from the producer, other than that in the steam supplied for blowing was, therefore,

$1958.5 - 19 + 135.7 = 2075.2$ kg.

$2364.2 - 2075.2 = 289$ kg. hydrogen from the steam or, $289 \times 9 = 2601$ kg. water, introduced into the producer, during the test, in the form of steam.

10. Heat Introduced into the Producer by the Steam.—As the pressure of the steam was 25 lbs. (gage) at the injector, the heat carried in, in excess of sensible heat of water at atmospheric temperature, was

$2601 \times (646 - 24) = 1{,}617{,}822$ Calories.

11. Total Heat Introduced into the Producer.—$212{,}320{,}392 + 1{,}617{,}822 = 213{,}938{,}214$ Cal. = total heat (above 24° C) in coal, steam, and atmospheric moisture, introduced into the producer.

12. Heat Lost in the Ash.—From (2), there was 47.2 kg. of fixed carbon in the ash drawn from the producer.

$47.2 \times 8100 = 382{,}320$ Cal. in the ash.

$$\frac{382{,}320}{213{,}938{,}214} \times 100 = 0.2 \text{ per cent. loss.}$$

13. Heat in the Dry Producer Gas.—The total weight of dry producer gas was 115,657 kg. The average temperature of the producer gas was 580° C and, as the temperature of the atmosphere was 24° C, the mean temperature between the two was 302° C.

		Sp. ht.	
CO_2.....	0.1241	× 0.244	= 0.0303
O_2.....	0.0117	× 0.214	= 0.0025
CO.....	0.2424	× 0.256	= 0.0620
CH_4.....	0.0206	× 0.834	= 0.0172
H_2.....	0.0108	× 3.581	= 0.0387
N_2.....	0.5904	× 0.256	= 0.1513

0.3020 = specific heat of the dry producer gas at the mean temperature of 302° C.

115,657 × (580 — 24) × 0.3020 = 19,420,198 Cal. = sensible heat in the dry producer gas.

CO	115,657	× 0.2424 ×	2,436 =	68,294,302 Cal.
CH_4	115,657	× 0.0206 ×	12,200 =	29,066,917 Cal.
H_2	115,657	× 0.0108 ×	29,100 =	36,348,682 Cal.

133,709,901 Cal. = heat from combustibles in the producer gas.

19,420,198 + 133,709,901 = 153,130,099 Cal. = total heat in the dry producer gas.

14. Heat in the Tar of the Producer Gas.—319,319 × 0.00756 = 2414 kg. = tar, carried past the "Sampling Station A," in the producer gas.

	Sp. ht.	
2414 × (580 — 24) × 0.35 =	469,764 Cal.	= sensible heat.
2414 × 8889 =	21 458,046 Cal.	= heat of combustion.

219,27,810 Cal. = total heat in the tar.

15. Heat in the Soot of the Producer Gas.—319,319 × 0.00347 = 1108 kg. = soot carried past "Sampling Station A" in the producer gas.

	Sp. ht.	
1108 × (580 — 24) × 0.31	=	190,975 Cal. = sensible heat.
1108 × 8056		= 8,926,048 Cal. = heat of combustion.
		9,117,023 Cal. = total heat in the soot.

16. Heat in the Water Vapor in the Producer Gas.—From (5), there was 2506 kg. of water vapor in the producer gas, 1221 kg. from the air entering the producer and the remainder (1285 kg.) from the steam and coal.

Figuring the sensible heat in 1221 kg. of water vapor above 24° C and the total (sensible and latent) heat in 1285 kg. water vapor above 24° C (using the formula $0.447 \div 324 \times 10^{-6}t$ for specific heat of water vapor)

1221 × (580 — 24) × 0.545	=	362,917 Cal.
1285 × 880		= 1,130,800 Cal.
		1,493,717 Cal. = total heat in water vapor.

17. Total Heat in the Producer Gas at "Sampling Station A."—

Heat in dry gas	153,130,099 Cal.
Heat in tar	21,927,810 Cal.
Heat in soot	9,117,023 Cal.
Heat in water vapor	1,493,717 Cal.
	185,668,649 Cal. = total heat above 24° C.

18. Producer and Flue Losses.—

From (11), the total heat introduced into the producer	= 213,938,214 Cal.
From (17), the total heat in the producer gas at "Sampling Sta. A"	= 185,668,649 Cal.
	28,269,565 Cal.

$\frac{28,269,565}{213,938,214} \times 100 = 13.2$ per cent. loss (including the 0.2 per cent. loss in the ash).

19. Heat Lost in the Flue Gases.—From (2), the amount of carbon passing "Sampling Station A" in the producer gas was 20,993 kg.

The average analysis of the flue gases (Table 2) shows:

	Per cent.
CO_2	10.49 (by volume)
CO	0.12
CH_4	0.10
	10.71 of carbon-bearing gases.

TABLE 2.—ANALYSES OF FLUE GAS.

Sample	A.	B.	C.	D.	E.	F.	G.	H.
CO_2	4.1	4.3	8.7	11.4	11.5	12.8	12.7	13.6
O_2	16.1	15.2	9.7	7.1	6.4	4.7	4.8	3.6
CO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CH_4	..	..	..	..	..	..	..	..
H_2	..	..	..	..	..	..	..	..
N_2	79.8	80.5	81.6	81.5	82.1	82.5	82.5	82.8
Per cent. excess air	314.0	244.0	81.0	49.0	42.0	27.0	28.0	20.0

Sample	I.	J.	K.	L.	M.	N.	O.	P.
CO_2	11.9	10.5	12.1	11.3	11.20	10.0	12.5	9.2
O_2	5.7	6.7	5.4	5.7	4.0	3.7	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.2	0.4	0.6	0.8
CH_4	..	..	..	..	0.2	0.3	0.5	0.6
H_2	..	..	..	..	1.1	2.1	3.2	4.2
N_2	82.4	82.8	82.5	83.0	83.3	83.5	83.2	85.2
Per cent. excess air	35.0	44.0	33.0	35.0	15.0	9.0	—11.0	—14.0

$0.1071 \times 12 = 1.2852$ g. = weight of carbon in the carbon-bearing gases in one gram-molecular volume of flue gases at 0° C.

$\frac{20,993,000}{1.2852} = 16,334,423$ gram-molecular volumes of dry flue gas.

The weight of one gram-molecular volume of dry flue gas was

		Per cent.
CO_2	$0.1049 \times 44 = 4.6156$	= 15.500
O_2	$0.0618 \times 32 = 1.9776$	= 6.650
CO_2	$0.0012 \times 28 = 0.0336$	= 0.112
CH_4	$0.0010 \times 16 = 0.0160$	= 0.054
H_2	$0.0066 \times 2 = 0.0132$	= 0.044
N_2	$0.8245 \times 28 = 23.0860$	= 77.640
	Total, 29.7420 g.	100.00

$\therefore$ 16,334,423 × 29,742 = 485,818 kg. = the total weight of dry flue gases. As the average temperature of the dry flue gases was 344.7° C, and of the atmosphere 24° C the specific heat of the gases at the mean temperature (184° C) was

		Sp. ht.
CO_2.....	0.15500 × 0.2239	= 0.0347
O_2.....	0.06650 × 0.2200	= 0.0146
CO.....	0.00112 × 0.2507	= 0.0003
CH_4.....	0.00054 × 0.7456	= 0.0004
H_2.....	0.00044 × 3.5104	= 0.0015
N_2.....	0.77640 × 0.2507	= 0.1946
		0.2461 = specific heat of the dry gases.

485,818 × (344.7 — 24) × 0.2461 = 38,342,831 Cal. = sensible heat in the dry flue gases.

CO.....	485,818 × 0.00112 × 2,436 =	1,325,467 Cal. in the unconsumed CO.
CH_4.....	485,818 × 0.00054 × 12,200 =	3,200,569 Cal. in the unconsumed CH_4.
H_2.....	485,818 × 0.00044 × 29,100 =	6,220,414 Cal. in the unconsumed H_2.
		10,746,450 = Cal. heat in the unconsumed combustibles in the flue gases.

16,334,423 × 0.8245 = 13,467,732 gram-molecular volumes of nitrogen in the flue gases.

Deducting the nitrogen in the producer gas as found under (6).

13,467,732 — 2,420,398 = 11,047,334 gram-molecular volumes of nitrogen.

$\frac{11,047,334}{0.792}$ = 13,948,654 gram-molecular volumes of dry air, which entered the kiln through the burners.

$\frac{13,948,654 \times 22.3}{1000}$ = 311,055 cu. m. of dry air at 0° C.

$\frac{311,055}{273} = \frac{x}{273 - 24}$.

x = 338,400 cu. m. dry air at 24° C.

$338{,}400 \times \frac{756}{739.46} = 345{,}969$ cu. m. of moist atmosphere at 24° C.

As there was present an average of 16.1 g. of water vapor per cu. m. of atmosphere (Fig. 7), $\frac{345{,}969 \times 16.1}{1{,}000} = 5570$ kg. of water vapor entering the kiln with the air required for combustion and the excess air.

From (8), the total hydrogen in the producer gas was 2364.2 kg.

The hydrogen, other than that in the moisture, escaping the flue gases was

CH_4.....	485,818 × 0.00054 × 4/16	= 65.6 kg.
H_2.....	485,818 × 0.00044	= 213.6 kg.
		279.2 kg.

Assuming that all of the free hydrogen found in the flue gases came from the producer:

2364.2 — 279.2 = 2085 kg. of hydrogen or 16,680 kg. of water vapor in the flue gases coming from the producer gas. 5570 + 16,680 = 22,250 kg. of water vapor, which left the kiln in the flue gases in addition to that which came from the ware.

The moisture entering with the air at the producer and with the air for combustion at the kiln was 1221 + 5570 = 6791 kg.

22,250 — 6791 = 15,459 kg. of water vapor evaporated or produced within the producer and the kiln.

6791 × (344.7 — 24) × 0.507 = 1,104,272 Cal. sensible heat above 24° C in the water vapor from the air.

15,459 × 740 = 11,439,660 Cal. total heat above 24° C in the water vapor from the steam and coal.

38,342,831 Cal.
10,746,450 Cal.
1,104,272 Cal.
11,439,660 Cal.

61,633,213 Cal. = total heat ost in the flue gases other than that leaving in the water vapor from the ware.

$$\frac{61,633,213}{213,938,214} \times 100 = 28.8 \text{ per cent. loss.}$$

20. Heat in the Mechanical and Hygroscopic Water.—The kiln setting consisted of 71,706 brick, which weighed when burned 175,402 kg.

The ignition loss of the clay was 3.39 per cent.

$$\therefore \frac{175,402}{1.00 - 0.0339} = 181,557 \text{ kg.} = \text{weight of the green ware set (dry basis).}$$

The green ware as set contained 0.543 per cent. mechanical and hygroscopic water.

$$\therefore \frac{181,557}{1.00 - 0.00543} = 182,548 \text{ kg.} = \text{weight of the damp green ware as set.}$$

182,548 — 181,557 = 991 kg. = mechanical and hygroscopic water in the ware.

Assuming the mean temperature of evaporation of the mechanical and hygroscopic water to be 125° C (the corresponding

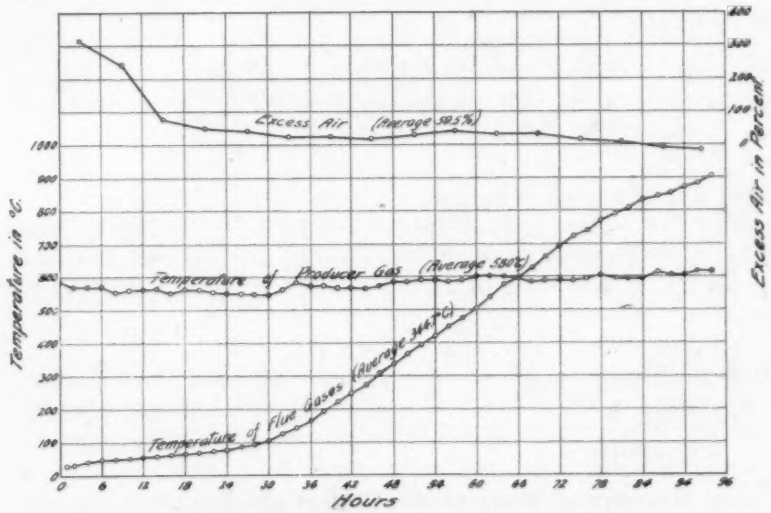
Excess Air (Average 39.5%)
Temperature of Producer Gas (Average 590°C)
Temperature of Flue Gases (Average 344°C)
Temperature in °C.
Excess Air in Percent
Hours

FIG. 8.—Producer gas and flue gas temperatures and excess air.

temperature of the flue gases (Fig. 8) being about 60° C), the heat leaving the kiln in this water vapor was

$$991 \times (125 - 24) = 100{,}091 \text{ Cal.}$$
$$991 \times 522 = 517{,}302 \text{ Cal.}$$
$$617{,}393 \text{ Cal.}$$

As this water vapor cooled down to 60° C, it gave up heat as follows:

$991 \times (125 - 60) \times 0.477 = 28{,}812$ Cal.

$\therefore 617{,}393 - 28{,}812 = 588{,}581$ Cal. = net loss.

$\frac{588{,}581 \times 100}{213{,}936{,}214} = 0.3$ per cent.

21. Heat Consumed in the Dehydration of the Clay and Leaving in the Vaporized Chemical Water in the Flue Gas.—From (20) the weight of the dry green ware was 181,557 kg. The burned weight of the ware was 175,402 kg.

$\therefore 181{,}557 - 175{,}402 = 6155$ kg. = approximate weight of the chemical water.

The temperature of the maximum rate of dehydration of clays is about 560° C.

$$6{,}155 \times (560 - 24) \times 0.2 = 659{,}816 \text{ Cal.}$$
$$6{,}155 \times 609 = 3{,}748{,}395 \text{ Cal.}$$
$$6{,}155 \times 261 = 1{,}606{,}455 \text{ Cal.}$$
$$6{,}014{,}666 \text{ Cal.}$$

The flue temperature corresponding to a kiln temperature of 560° C was (from curve—Fig. 8) about 150° C and the heat given up by this water vapor, on cooling from 560° C to 150° C, was

$6{,}155 \times (560 - 150) \times 0.562 = 1{,}418{,}235$.

$\therefore 6{,}014{,}666 - 1{,}418{,}235 = 4{,}596{,}431$ Cal. = net consumption.

$\frac{4{,}596{,}431 \times 100}{213{,}938{,}214} = 2.2$ per cent.

22. Heat in the Ware at the End of the Burn.—At the end of the burn the temperature of the ware 4′ above the floor

averaged 1135° C (Fig. 9), the temperature through the center of the crown was 1135° C, and the temperature at the floor level was 1070° C. Assuming that the level of 4′ above the floor divided the mass of ware into halves, taking the temperature

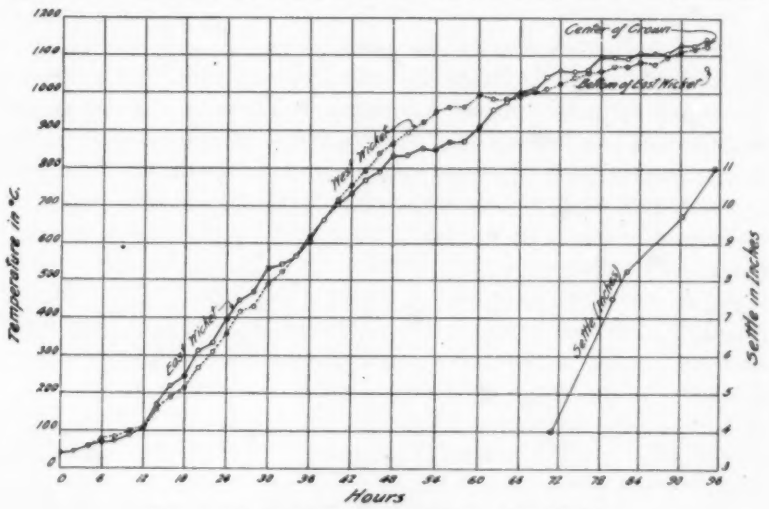

FIG. 9.—Internal Kiln Temperatures and Settle.

of the upper half as 1135° C and the temperature of the lower half as the average between 1135° C and 1070° C or approximately 1100° C, then the temperature of the whole mass can be considered as the average between 1100° C and 1135° C or 1118° C.

As the weight of the burned ware was 175,402 kg., the heat represented in this ware at the end of the burn was

$$175{,}402 \times (1118 - 24) \times 0.23 = 44{,}135{,}011 \text{ Cal.}$$

$$\frac{44{,}135{,}011 \times 100}{213{,}938{,}214} = 20.6 \text{ per cent.}$$

23. Heat in the Kiln Structure and in the Ground at the End of the Burn and the Radiation Loss.—The losses previously calculated amount to 65.1 per cent.

100 — 65.1 = 34.9 per cent. of the total heat was stored up at the end of the burn in the kiln structure and in the ground under and around the kiln and was lost by radiation during the burn.

As soon as the fires were cut off at the end of the burn, temperature readings of the external surface of the kiln were taken at numerous places on the crown and side walls, by means of a copper-constantan couple, of small gauge, and a potentiometer.

The average temperature of the exterior of the crown was 130° C, the exterior of the side wall above the hob 78° C, and the exterior of the hob 46° C. Knowing the internal and external temperatures, curves were drawn indicating the probable temperature throughout the cross section of the several parts and, from these, average mass temperatures were secured. Crown 477° C, side wall 429° C, and hob 423° C. Then, the heat contained in the kiln structure above the ground was as follows:

Crown.....	49,432 × (477 — 24) × 0.23 =	5,150,320 Cal.
Side wall.....	45,562 × (429 — 24) × 0.23 =	4,244,100 Cal.
Hob.....	45,017 × (423 — 24) × 0.23 =	4,131,210 Cal.
		13,525,630 Cal.

$$\frac{13,525,630 \times 100}{213,938,214} = 6.3 \text{ per cent.}$$

The heat stored up in the kiln bottom and in the ground, below and around the kiln, and the heat radiated during the burn was

$$34.9 - 6.3 = 28.5 \text{ per cent.}$$

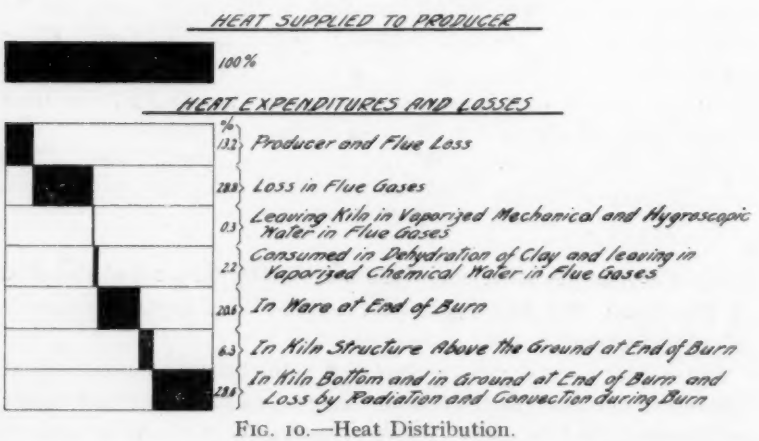
HEAT SUPPLIED TO PRODUCER
100%
HEAT EXPENDITURES AND LOSSES
%
13.2 Producer and Flue Loss
28.8 Loss in Flue Gases
0.3 Leaving Kiln in Vaporized Mechanical and Hygroscopic Water in Flue Gases
2.2 Consumed in Dehydration of Clay and leaving in Vaporized Chemical Water in Flue Gases
20.6 In Ware at End of Burn
6.3 In Kiln Structure Above the Ground at End of Burn
28.6 In Kiln Bottom and in Ground at End of Burn and Loss by Radiation and Convection during Burn

FIG. 10.—Heat Distribution.

V. Conclusion.

The coal consumption was 989 lbs. per 1000 brick.

No direct means was available for measuring the steam supplied to the producer, hence it was necessary to derive the amount by calculation. The results indicate that a smaller quantity of steam was used than in normal producer practice. This was to be expected, however, as the steam was cut off from the bosh and entered only through the center tuyère.

Using the external kiln temperatures, secured at the end of the burner, time-temperature curves were drawn indicating the probable surface temperatures throughout the burn for the several parts of the kiln. From these curves were secured the average temperatures as follows: Crown 74° C, side walls 41.6° C, and hob 31° C. Using the formula of Peclet for radiation and convection, the total radiation and the convection loss from the exterior surface of the kiln was calculated to be 4.8 per cent. This is undoubtedly too low and the figures were not included as a part of the calculation. However, attention should be called to the unusually low external kiln surface temperatures, which, together with the short duration of the burn, would necessarily result in a low radiation loss. In the author's opinion, the total radiation and convection losses from the kiln structure, including the burners, was not over 15 per cent. and possibly as low as 10 per cent.

The coal was elevated mechanically to the producer charging floor and all coal and ash handling was centralized.

The advantage of a clear kiln yard, with entire absence of coal and ash piles, need hardly be argued.

Where no space is necessary for piling coal, the kilns may be placed closer together, resulting in a more compact kiln yard.

As the producer and flue loss, as indicated in the calculation, was over 13 per cent., the use of a producer, from the standpoint of heat generation only, cannot be considered more efficient than the combustion of coal in the kiln furnaces, but an advantage lies in the ability to control the application of the gas to the kilns. This is brought out clearly by the record of excess air in the flue gases, indicated in Table 2 and Fig. 8. This air excess is much lower than in most direct-coal-fired kilns.

Either oxidizing or reducing conditions, to any degree, may be had at will and change from the one condition to another can be effected almost instantaneously.

Only a limited amount of solid fuel can be burned in direct-fired-kiln furnaces. Except by increasing the draft through the grates, the amount of fuel consumed can be increased only by increasing the grate area. In the gas-fired kiln, there is no such limitation, with the result that the heat application, at safe periods during the burn, can be made at a much greater rate than in the case of solid fuel direct-fired.

One burner and one producer man handled the burning in 12-hour shifts. The boiler fireman removed the ashes from the producer. On Sundays, the day burner looked after the boiler and removed the ashes from the producer, if necessary.

When the number of direct-fired kilns is increased to such an extent that one burner cannot take care of them, then the producer-gas-burning system would show a saving in labor, but there is no great relative reduction in labor for a small gas installation.

Producer gas has a lower flame temperature than coal, direct fired. Producer gas with its inert constituents—nitrogen, carbon-dioxide and water vapor—loses a considerable part of its sensible heat in traveling from the producer to the burners, in addition to the loss due to "cracking." These inert gases, acting as a dilutant to the combustible mixture, reduce the resulting combustion temperature. In view of this, it is unreasonable to expect very high temperatures from producer gas, when using air at atmospheric temperatures to support combustion.

The advantages and disadvantages of this system may be summarized as follows:

Advantages:

1. Centralization of coal and ash.
2. Clean kiln yard.
3. Reduced kiln yard space.
4. Combustion control.
5. Generation of a large amount of heat in a limited furnace space.

6. Quick burns.
7. Labor saving when the capacity exceeds a one-man unit.

Disadvantages:

1. Producer and flue losses.
2. Lower flame temperature.

DISCUSSION.

MR. BLAIR: I would like to ask Mr. Harrop if his producer losses were offset by the better control of excess air in the kiln? You stated that the grate would burn with approximately 900 pounds of coal per 1000 brick. What could they do with coal combusted in the fire boxes direct? Could they do as well as that?

MR. HARROP: In my judgment, the saving due to the well-nigh perfect control that they were able to get in the way of excess air and the ease of manipulation of the combustion conditions would fully cover the producer losses. I am sure that if the saving in the reduction of excess air would not cover the producer losses, that the other advantages would. It could be calculated, quite readily, whether the expenditure of fuel to heat a normal amount of excess air over what we found, would equal or be in excess of 13 per cent. It would be very interesting to see whether it would cover or exceed the loss in the producer.

MR. MONTGOMERY: I would like to ask Mr. Harrop to please repeat his statement in regard to the maximum temperatures reached in a periodic kiln, using producer gas with cold air. He said something about reaching cone ten in the bottom of the kiln.

MR. HARROP: That was a continuous kiln which was being fired with a very poor grade of lignite, and the man who reached cone ten said he stopped the kiln, not because he could not reach a higher cone, but because he feared the kiln would be damaged.

MR. MINTON: I would like to ask, what was the height and diameter of the stack and how high were the inside walls?

MR. HARROP: The stack is 40 feet high and I think the division walls extend to the top of the stack.

MR. ORTMAN: It seems to me that a statement from Mr. Harrop as to his observations of the temperatures of the fire boxes in this case as compared with observations made on direct-coal-fired methods and the probable effect that the difference in temperature, if any, would have on kiln repair, might form a very valuable addition to the record in connection with this kiln.

MR. HARROP: This test was made about a year and a half ago—my remembrance is that there were no enclosed fire boxes, similar to those used for burning solid fuel, but that the hole or opening through the side wall was very small. There was a bag wall, to be sure, but I do not believe that the temperatures reached in what you might call the fire boxes are as high as the temperatures reached in the combustion of solid fuel.

NOTES ON THE HYDRATION OF ANHYDRITE AND DEAD-BURNED GYPSUM.

By A. C. Gill, Ithaca, N. Y.

In the prosecution of certain studies which, in accordance with the plans of the late H. E. Kramm, of Cornell University, were to have led up to an exhaustive discussion of the properties and conditions of the formation of gypsum and anhydrite, two experiments were inaugurated, the results of which have recently come to light. These seem worthy of record both on account of their intrinsic interest and as a tribute to the painstaking methods of Mr. Kramm. The object of this investigation seems to have been to determine the extent to which time might be a factor in the "setting" of anhydrite and dead-burned gypsum. As is well known, for short periods of time, these substances show little or no tendency to set.

The experiments were conducted in two wide-mouthed bottles or cylindrical jars having metallic screw-caps, but without rubber rings for air-tight sealing. Each jar was a little more than one and a half inches in diameter, and slightly less than six inches high, having thus a capacity of about 250 cc. In one was placed some 50 or 60 grams of anhydrite from Windsor, N. S., broken approximately fine enough to pass through a sieve of six or eight meshes to the inch. The other was charged with several lumps of Hillsboro, N. B., alabaster which had been heated for three and a half hours to a maximum temperature of 560° C, the lumps being an inch or more in greatest diameter, and having an aggregate volume of perhaps 60 or 75 cc.

Both bottles were filled with water and closed on Oct. 28, 1911. Late in 1917, a little more than six years after the beginning of the experiment, they were discovered with their carefully prepared labels still intact. A striking appearance was presented, as shown by the two photographs (Figs. 1 and 2) which were made after cutting off the tops of the bottles. The water

had entirely evaporated from both specimens. They may perhaps be best described separately.

I. Anhydrite. (See Fig. 1.)

The small fragments of anhydrite were so firmly bound together that it was impossible to pry them out for analysis without breaking to a coarse powder. Glistening crystals of gypsum could be seen in the interstices, and brilliant, acicular crystals, attaining a maximum length of about one-half inch, projected

FIG. 1.

Consolidated anhydrite with gypsum needles, formed within a period of six years.

into the free space which had been occupied by the water. These crystals gave very good reflections on a Fuess goniometer, showing by their prism angle of 68° 39′, that they are elongated in the direction of the *c* axis.

In order to determine to what extent hydration had taken place, about half a gram (0.4475 g.) of the material was dug out with a heavy knife point, avoiding as far as possible the visible

gypsum crystals. On heating to constant weight at low red heat the loss was found to be 8.29 per cent. (37.1 mg.). This corresponds to a hydration into gypsum of 34.15 per cent. of the original anhydrite. It shows conclusively that the hydration was not limited to the amount of calcium sulphate which could be held in solution at one time, since all the water originally present would dissolve less than half a gram of that substance, while fifteen or twenty grams of the anhydrite must have been hydrated.

Unfortunately, no data is at hand to indicate how much of the "setting" was due to temperature changes, thus leaving in doubt the extent and rate of recrystallization which would take place at constant temperature. That the anhydrite fragments were firmly cemented by gypsum crystals, under the existing conditions, is fully established.

II. Dead-burned Gypsum. (See Fig. 2.)

The pieces of burned alabaster in the second bottle had become veritable porcupines with a complete covering of fine bristling gypsum needles about one-eighth of an inch in length. Inside the spiny coating, the mass had "set" to much greater hardness than ordinary plaster of Paris. By means of heavy forceps a portion was cut from one of the lumps, and, after the crystals were broken away from its surface, a water determination was made by the method of loss. Nearly a gram of the material (0.9865 g.) lost 18.8 per cent. (185.4 mg.). This indicates a re-hydration of 87.46 per cent. of the calcium sulphate of the burned gypsum. The difference in behavior between this substance and the anhydrite is very marked, the water seemingly finding its way back to its place in the dehydrated gypsum much more readily than it could make place for itself in the crystallized anhydrite. The smaller amount of water, larger amount of calcium sulphate, and the greater degree of hydration, make the argument against simple solution and subsequent evaporation even more compelling in this case than in that of anhydrite.

A further phenomenon should be noted as having a bearing on the significance of this experiment. The bottle was found to have a vertical crack from the top almost to the bottom. Through

it the water had evidently oozed and by evaporation a small amount of gypsum was deposited on the outside of the bottle. It seems almost certain that this crack was produced by the ex-

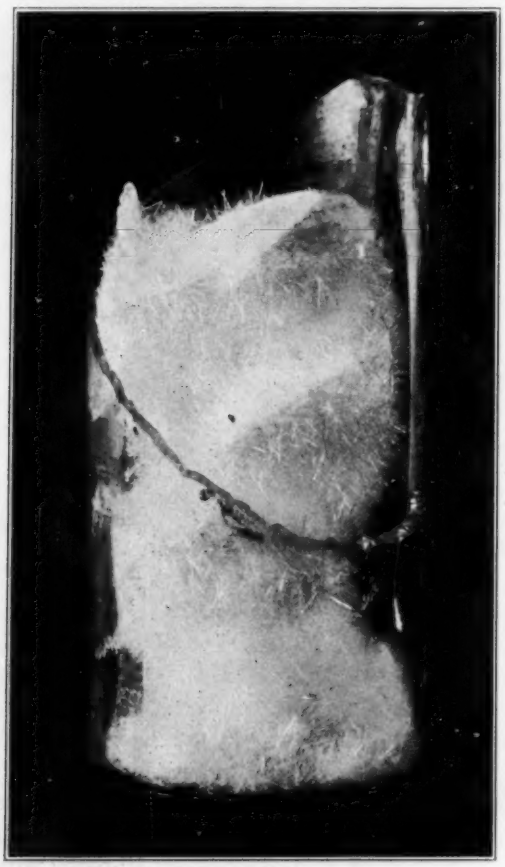

FIG. 2.

Fragments of "dead-burned" gypsum, with coating of recrystallized gypsum needles.

pansive force of hydration or by the growing force of the gypsum crystals. Mr. Kramm would hardly have used a cracked bottle and if the crack had existed during the whole of the experiment,

it would seem that the water would have escaped before producing such extensive changes. The crack would allow of more rapid desiccation, however, and this may explain the smaller size of the gypsum needles in this bottle.

The fact that, in both bottles the multitude of acicular crystals were all attached to the masses of introduced sulphate and none to the glass walls, would seem to corroborate Taber's view—that the crystals grow at the point of attachment rather than at the free end.

In conclusion, while emphasizing the fact that under the conditions of these experiments both natural anhydrite and "dead-burned" gypsum attained a firm "set," it may be pointed out that there is room for further investigation as to the rate at which this takes place, since no observation was made as to the time when evaporation was complete. Moreover, the question of the relative importance of temperature changes, causing supersaturation by cooling, and of constant temperature hydration and crystallization, due to the greater solubility of $CaSO_4$ than of $CaSO_4 + 2\ H_2O$, is raised rather than answered.

COMMUNICATED DISCUSSIONS.

F. A. KIRKPATRICK: The hydration of anhydrite is interesting from a geological point of view. Certain gypsum deposits have evidently been formed by the weathering of the anhydrite which is found beneath the gypsum. The rate of hydration in nature is probably much slower than that observed in the laboratory, as the conditions in the latter case were very favorable for hydration. Anhydrite is not used as a material of construction since it hydrates and sets too slowly.

The hydration of burned gypsum presents a practical problem of great interest. There still remains a large amount of experimental work to be done along this line. The well-known investigation of Glasenapp on Hydraulic Gypsum should be extended to include strength tests. If we should accept Glasenapp's classification of burned gypsum products, the sample of Hillsboro alabaster heated for three and a half hours to a maximum temperature of 560° C would be completely dehydrated.

In contact with water it would show, in short periods of time, no hardening or only imperfect hardening. It would contain little or no hydraulic gypsum. In the long period of storage, about six years, the material used would hydrate and set slowly, probably mostly by crystallization. The introduction of alum or other catalyzers would decrease the time of set sufficiently to allow the material to be used for practical purposes.

W. E. EMLEY: Mr. Gill has established one point which is of great interest and importance to the gypsum industry, *viz.*, that both anhydrite and dead-burned gypsum will hydrate if given sufficient time.

The ordinarily accepted theory of the setting of gypsum, as applied in this case, would be that the water dissolves the anhydrous calcium sulphate which, subsequently, crystallizes out in the form of the less soluble hydrated gypsum.

Theoretically, a small amount of water could continue to dissolve anhydrite and deposit gypsum indefinitely. The quantity of water required is not at all dependent upon the solubility of the anhydrite, but depends solely upon the fact that the gypsum which is deposited carries with it two molecules of water for each molecule of calcium sulphate.

Mr. Gill leads one to infer that he believes his experiments have thrown some doubt upon the working of this theory; I cannot see that this is the case. I believe that the fact that his dead-burned gypsum hydrated to a greater extent than his anhydrite is due to the greater speed of reaction rather than to the relative quantities of water present. I believe that in both cases, the reactions continued until the water left as such was not sufficient to supply the two molecules necessary for the crystallization of the calcium sulphate held in solution.

The dead-burned gypsum was apparently more active than the anhydrite, and therefore was able to hydrate to a greater extent before the water had evaporated.

I believe that the experiment does prove conclusively that anhydrite and dead-burned gypsum will set; I believe that it also proves that dead-burned gypsum, formed under the conditions of the experiment, sets more rapidly than anhydrite.

I do not believe that the experiment throws any particular light on the mechanics of the setting, because the two most important elements were not observed, *viz.*, the time and the temperature.

A. C. GILL: The discussions of Messrs. Kirkpatrick and Emley lead me to emphasize the fact that the experiments with anhydrite and dead-burned gypsum were inaugurated and planned by Mr. Kramm. The present paper is merely an attempt to salvage some of the results which he would have attained if he had lived to complete the investigation.

Mr. Kramm doubtless intended the time and temperature of heating the Hillsboro alabaster to insure complete dehydration. He may even have carried out analyses to confirm this, though no such record is known to me. The possibility of using alum as an accelerator, as suggested by Mr. Kirkpatrick, is worthy of careful consideration.

As to Mr. Emley's discussion, it may be pointed out that the formation of gypsum crystals, to which the setting of the substances under investigation is supposed to be due, may take place from solution or simply by the addition of two molecules of water to each one of calcium sulphate, without the latter substance passing into solution. If from solution, it doubtless would go on at constant temperature when saturation for calcium sulphate was reached. But what the relative rate of setting would be at constant temperature, as compared with that produced by the diurnal temperature change of the laboratory, does *not* appear from the experiment. Nor is there any indication of the relative importance of setting without solution. Under the conditions of the experiment, it is certain that the relative quantities of water present may have had a great influence on the time required to reach saturation.

MEETINGS OF THE LOCAL SECTIONS, AMERICAN CERAMIC SOCIETY.

(Full accounts of all meetings should be sent to the Editor, Box 444, New Brunswick, N. J.)

NORTHERN OHIO SECTION.

A meeting of the Northern Ohio Section was held in the afternoon and evening of June 10th, in Cleveland, Ohio. During the afternoon the following plants were visited:

Cleveland Metal Products Company, manufacturers of enameled lamp shades, stove parts, etc. The operations include pressing, oxyacetylene welding, electrical welding and enameling.

National Lamp Works, Euclid Glass Division, manufacturers of glass electric light bulbs. The points of interest were a Smith gas producer plant, the molding of glass melting pots and the manipulations in the manufacture of glass tubing and glass bulbs.

Nela Park Auditorium, Nela Park (Cleveland research laboratories of the General Electric Co.). An interesting illustrated lecture on the manufacture of electric lights was delivered by a member of the General Electric staff.

A joint meeting of the Section and the Cleveland Section of the American Chemical Society was held in the evening at the Olmstead Hotel. An instructive address on "Petrographic Studies in Ceramics" was delivered by A. A. Klein of the Research Laboratories, Norton Company, Worcester, Mass.

B. A. RICE, *Secretary.*

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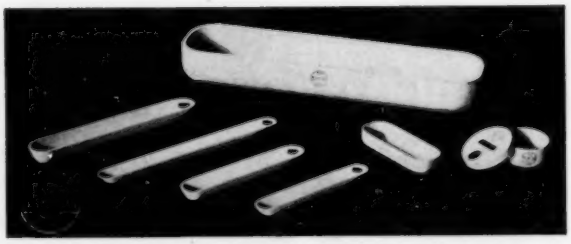

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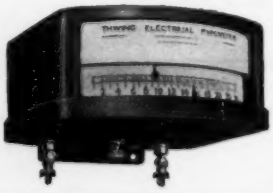

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